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Iddon et al.

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102(b)

[54] **NETWORK DATA COLLECTION METHOD AND APPARATUS**

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[21] Appl. No.: **549,323**

[22] Filed: **Oct. 27, 1995**

Related U.S. Application Data

[63] Continuation of Ser. No. 130,317, Oct. 1, 1993, abandoned.

[51] **Int. Cl.**^{6} **G06F 15/163**

[52] **U.S. Cl.** **395/200.11**; 395/200.02; 395/200.13; 395/415; 395/416; 395/417; 395/610; 395/616; 395/838; 364/DIG. 1; 364/242.94; 364/284.4; 364/269.4

[58] **Field of Search** 395/600, 200.11, 395/838, 200.02, 200.13, 415, 416, 417, 610, 616; 370/17, 60, 85.8, 94.1; 364/DIG. 1

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Current class 707/10

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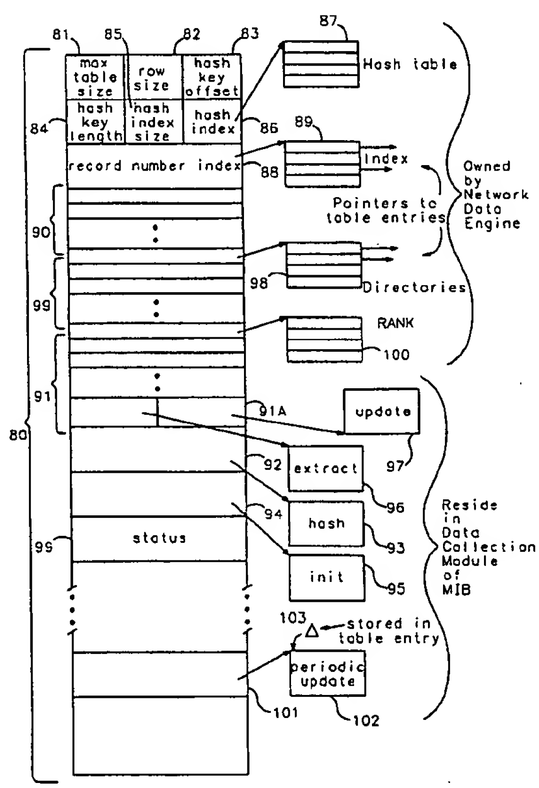
[57] **ABSTRACT**

Disclosed are a method and apparatus for collecting network data from a computer network. Control structures are created for groups of data to be collected. The control structures are then associated with corresponding tables for storing the data. Different control structures and extract functions are defined depending upon which data is to be collected, and the form in which the data is to be presented. These control structures and extract functions are then employed to avoid redundant data gathering efforts.

20 Claims, 8 Drawing Sheets



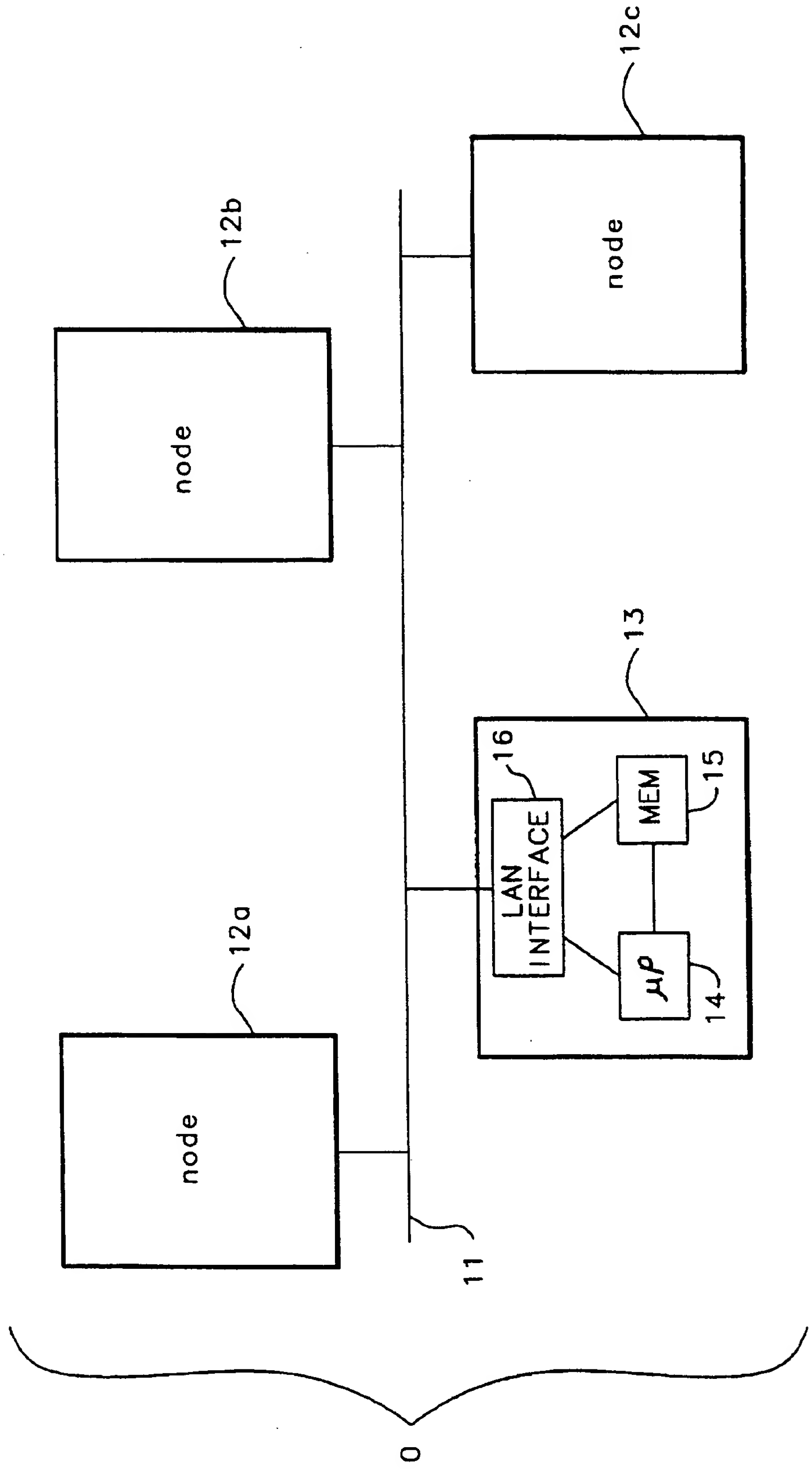

10
11
12a
node
12b
node
12c
node
13
LAN INTERFACE
16
MEM
15
μP
14

FIG. 1

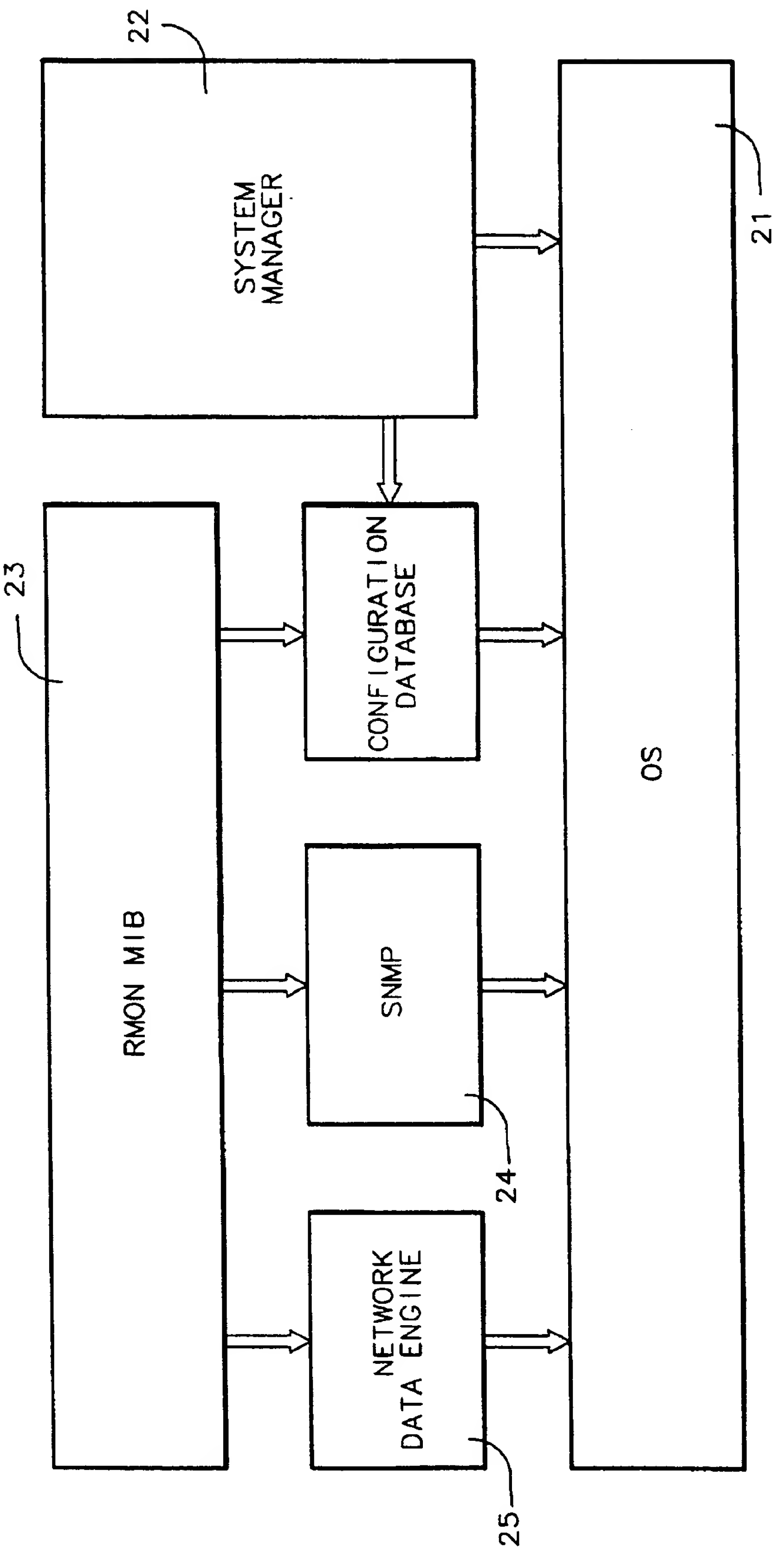

SYSTEM MANAGER
22
21
OS
RMON MIB
23
CONFIGURATION DATABASE
SNMP
24
NETWORK DATA ENGINE
25

FIG. 2

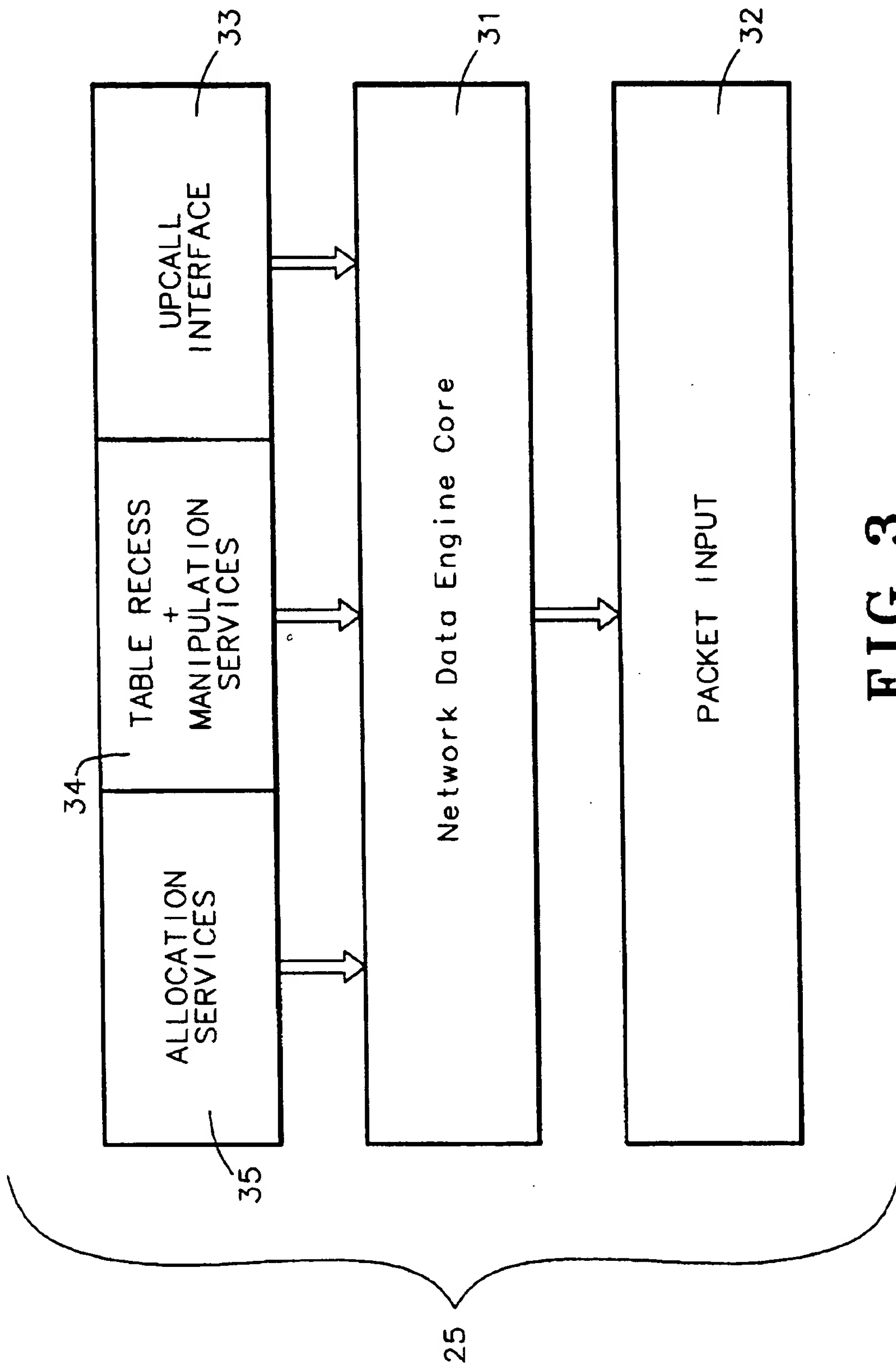

33
UPCALL INTERFACE
TABLE RECESS + MANIPULATION SERVICES
34
ALLOCATION SERVICES
35
31
Network Data Engine Core
32
PACKET INPUT
25

FIG. 3

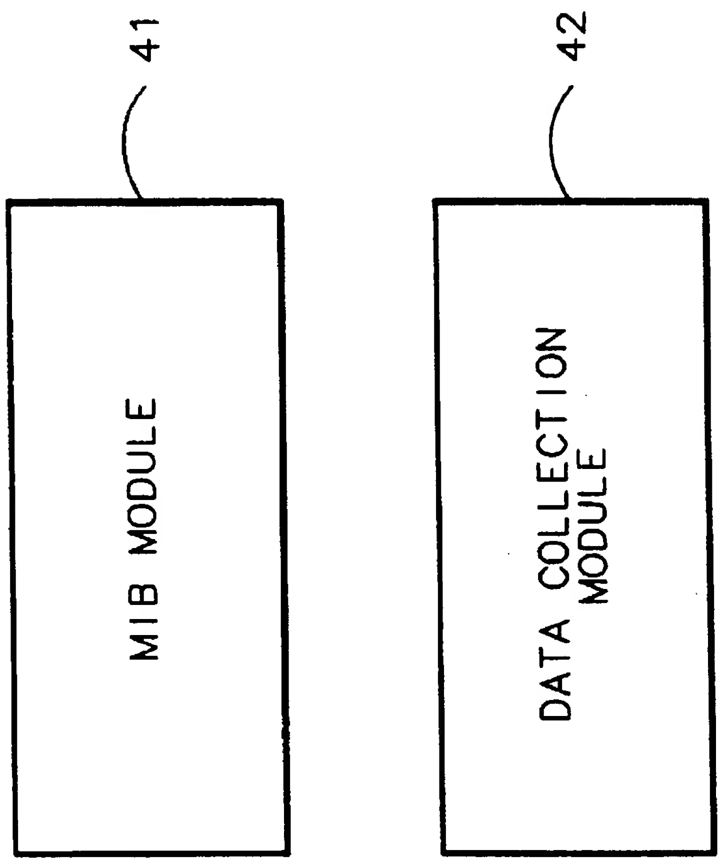


FIG. 4

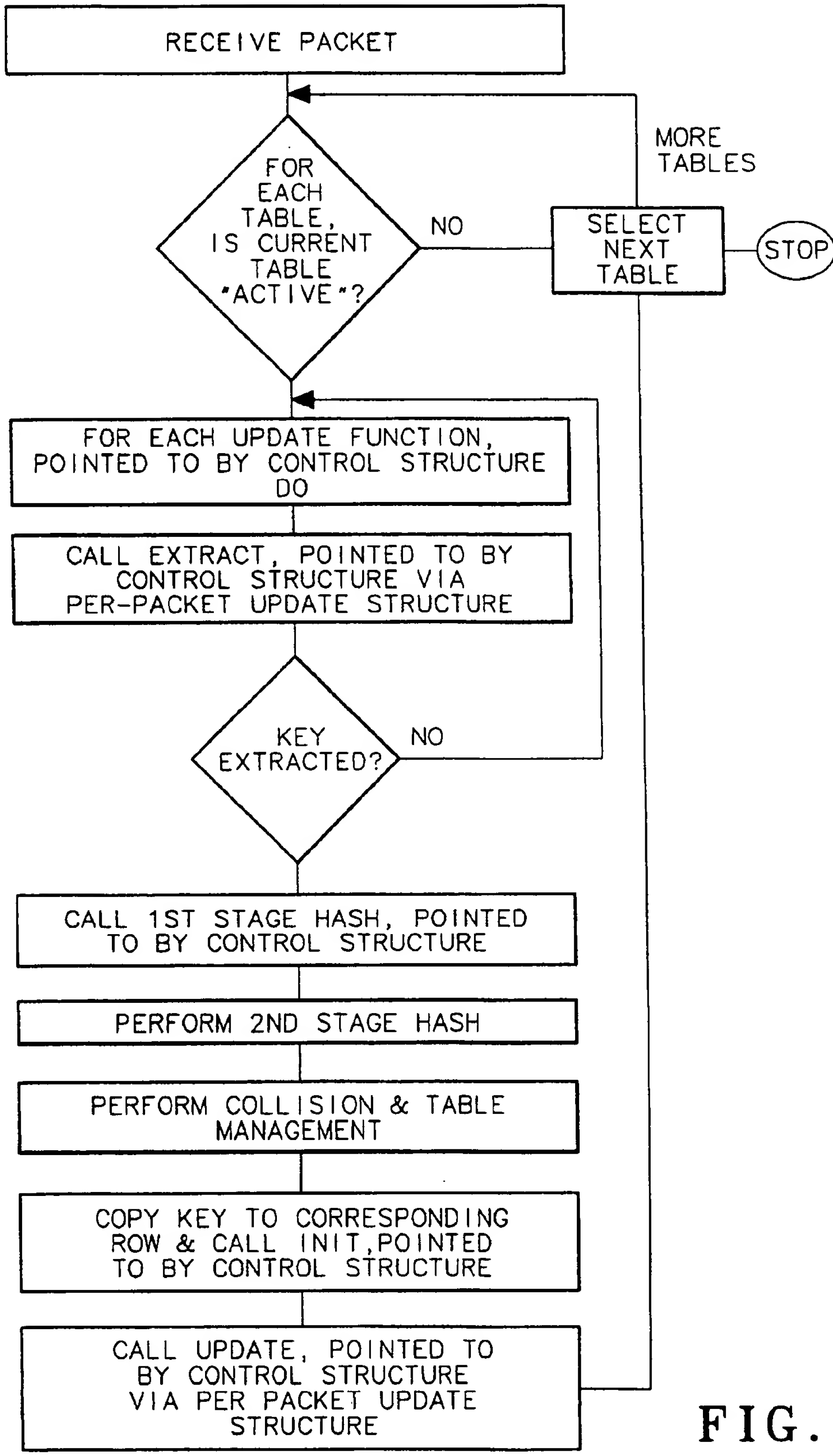

RECEIVE PACKET
MORE TABLES
FOR EACH TABLE, IS CURRENT TABLE "ACTIVE"?
NO
SELECT NEXT TABLE
STOP
FOR EACH UPDATE FUNCTION, POINTED TO BY CONTROL STRUCTURE DO
CALL EXTRACT, POINTED TO BY CONTROL STRUCTURE VIA PER-PACKET UPDATE STRUCTURE
KEY EXTRACTED?
NO
CALL 1ST STAGE HASH, POINTED TO BY CONTROL STRUCTURE
PERFORM 2ND STAGE HASH
PERFORM COLLISION & TABLE MANAGEMENT
COPY KEY TO CORRESPONDING ROW & CALL INIT, POINTED TO BY CONTROL STRUCTURE
CALL UPDATE, POINTED TO BY CONTROL STRUCTURE VIA PER PACKET UPDATE STRUCTURE

FIG. 5

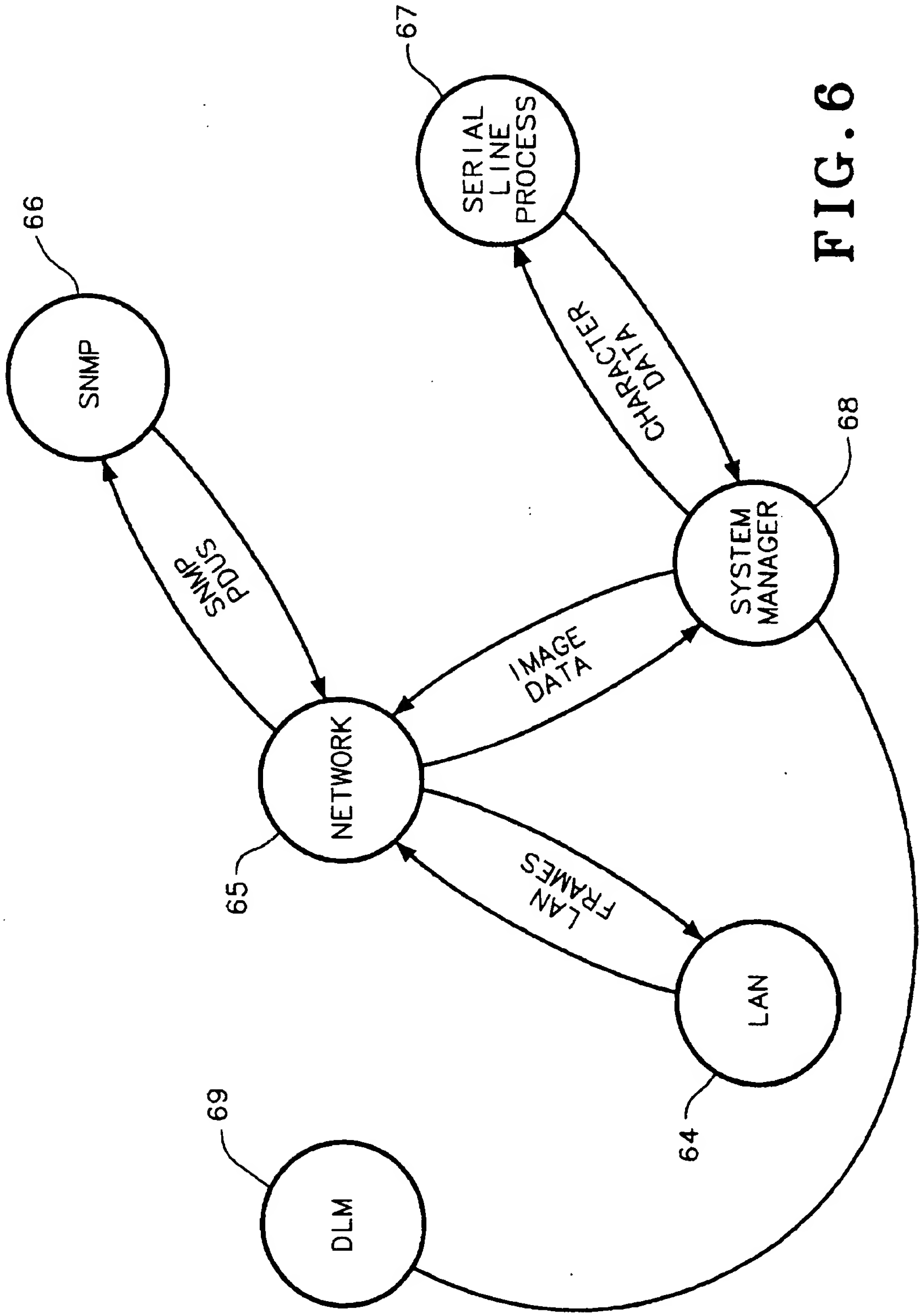

66
SNMP
67
SERIAL LINE PROCESS
CHARACTER DATA
SNMP PDUS
68
SYSTEM MANAGER
IMAGE DATA
NETWORK
65
LAN FRAMES
LAN
64
69
DLM

FIG. 6

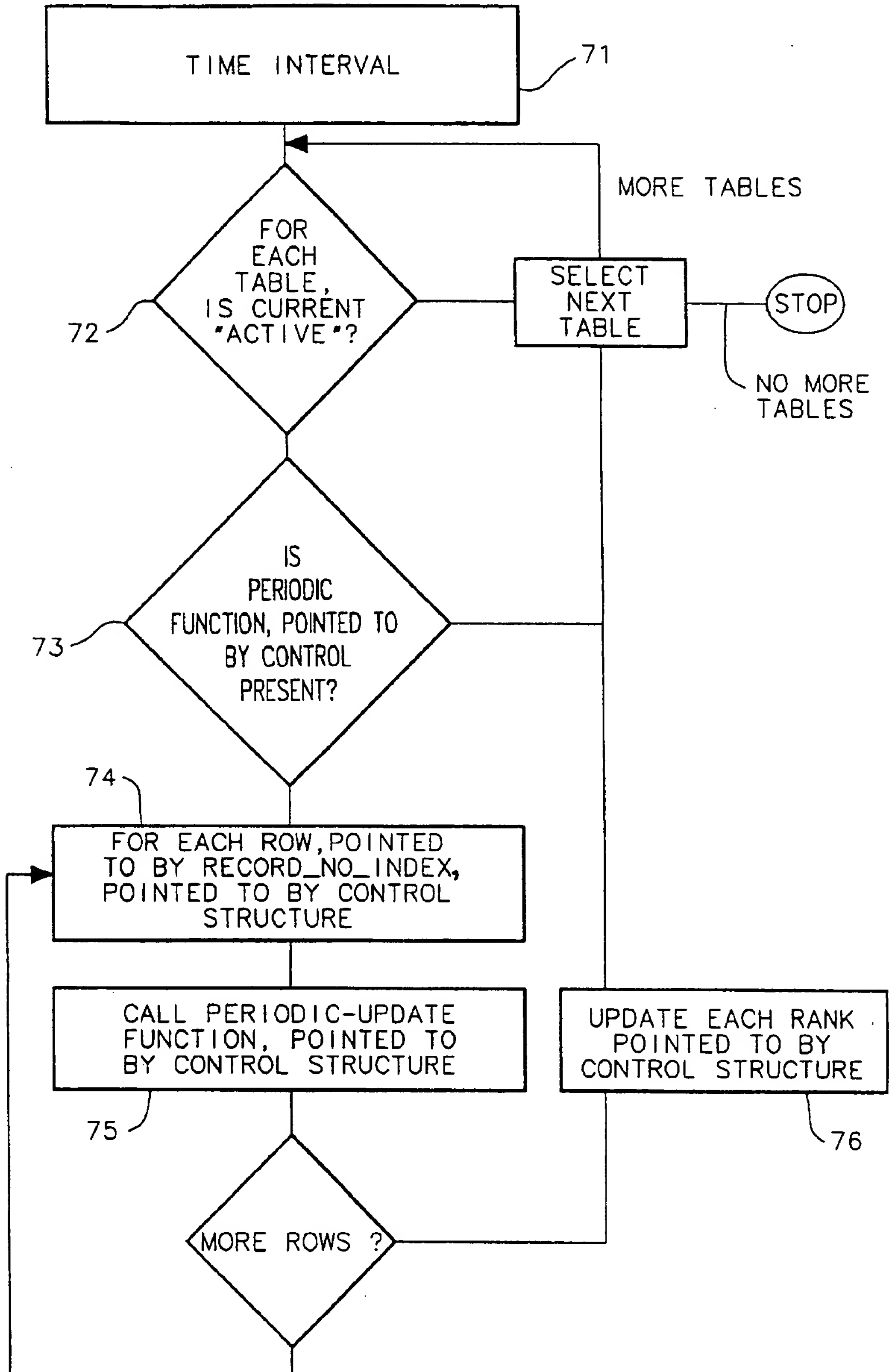

TIME INTERVAL
71
MORE TABLES
FOR EACH TABLE, IS CURRENT "ACTIVE"?
72
SELECT NEXT TABLE
STOP
NO MORE TABLES
IS PERIODIC FUNCTION, POINTED TO BY CONTROL PRESENT?
73
74
FOR EACH ROW, POINTED TO BY RECORD_NO_INDEX, POINTED TO BY CONTROL STRUCTURE
CALL PERIODIC-UPDATE FUNCTION, POINTED TO BY CONTROL STRUCTURE
75
UPDATE EACH RANK POINTED TO BY CONTROL STRUCTURE
76
MORE ROWS ?

FIG. 7

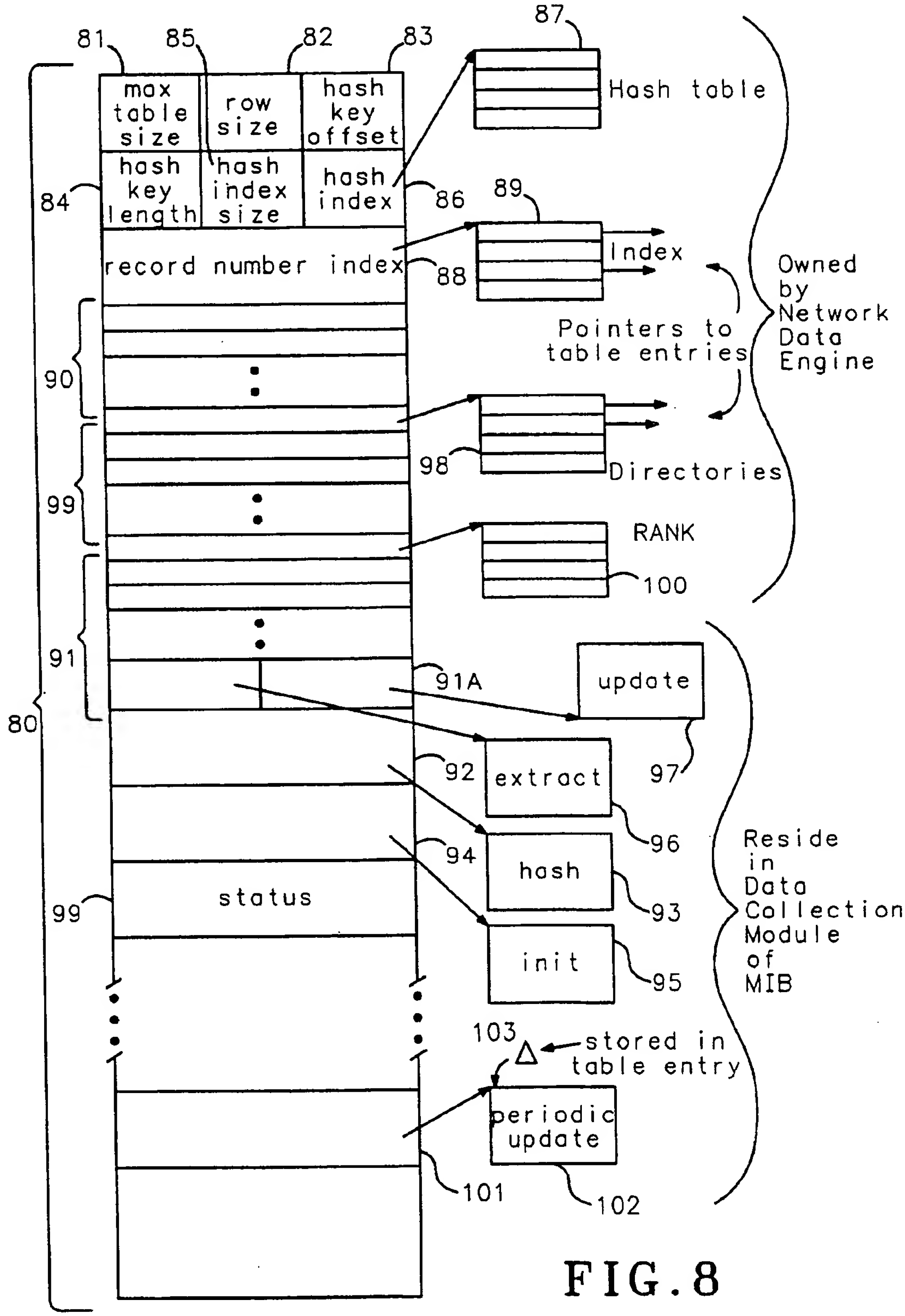

81
85
82
83
87
max table size
row size
hash key offset
Hash table
hash key length
hash index size
hash index
84
86
89
record number index
88
Index
Owned by Network Data Engine
Pointers to table entries
90
98
Directories
99
RANK
100
91
91A
update
80
97
92
extract
96
94
hash
93
Reside in Data Collection Module of MIB
99
status
init
95
103
stored in table entry
periodic update
101
102

FIG. 8

NETWORK DATA COLLECTION METHOD AND APPARATUS

This application is a file-wrapper continuation of application Ser. No. 08/130,317, filed Oct. 1, 1993, now abandoned.

FIELD OF THE INVENTION

The present invention relates to computer network management and, in particular, to collecting network data with a scalable data engine.

BACKGROUND OF THE INVENTION

Computers are commonly arranged into networks to allow intercommunication. Depending upon the interconnection technology, these networks can span great distances. Moreover, the networks can employ one or more communication protocols, devices may be added or removed from the network arbitrarily, communication paths may change, and the nature and characteristics of the network traffic is variable. As such, the management of these systems has become increasingly complex.

Among other things, network management typically entails determining which sections of a computer network are over- or under-utilized. In addition, it includes detecting and locating network faults so that repairs and/or re-routing of the network can be made, if necessary.

In order to perform these network management functions, network management tools have been developed to assist the MIS expert in managing the network. Network management tools employ software applications that allow the MIS expert to diagnose the network and thereby minimize maintenance cost by efficiently utilizing the MIS expert's time. Sometimes, these tools include dedicated hardware.

Some older network management tools performed these tasks by periodically polling certain devices connected to the network. A device connected to the network is commonly called a network node, or just node. This approach is sometimes referred to as the "ping" approach. Though this approach could determine connectivity and operability of the nodes, it could not effectively provide the full range of functionality that network professionals desired. For example, it was impractical for these systems to gather utilization statistics, and connectivity analysis is only a small portion of the task of isolating network problems.

Later, protocol analyzers were developed, which provided the capability of collecting basic statistics and filtering for and decoding of specific packets. It will be appreciated that the structure of a packet will depend upon the underlying protocol. However, protocol analyzers require a technician to take equipment to the problem, once it is discovered.

Still later, network management tools used dedicated nodes to monitor all of the network traffic passing the node. These dedicated nodes used embedded systems, i.e., microprocessors and memory storing task-specific software, to monitor network traffic passing the node. By judiciously placing these nodes into different network segments, the tools could gather information about all of the network traffic. These systems provide more functionality, but have stringent performance requirements, as they require the node to handle all network traffic passing the node.

Standards, such as SNMP, were eventually developed to facilitate development among different network management software suppliers (SNMP: Standard Network Management Protocol). SNMP outlines what statistical data

should be gathered and available to the network. Software developers can then write their applications, knowing that any system which complies with the standard will provide this data. These type of standards, among other things, facilitate the development of distributed network management.

Within SNMP, RMON MIB was developed as a standard management information base ("MIB"). It will be appreciated that a MIB is a collection of data and that a MIB is in no way limited to the RMON specification. For an Ethernet segment, RMON requires nine groups of data: Statistics Group; History Group; Host Group; Host TopN Group; Matrix Group; Alarm Group; Filter Group; Packet Capture Group and Event Group. This set of data is then available to the network management platform or other application. For token rings, RMON requires ten groups, the nine outlined above plus a token ring group.

SNMP effectively defines the network as a world full of objects, each having a type and value. SNMP does not instruct how this data ought to be collected and compiled. SNMP will not be further discussed herein, as it is known in the art.

Basically, this newer architecture has a plurality of dedicated nodes placed throughout the network. Each of these dedicated nodes is constantly gathering information about its corresponding network segment. This process of gathering information is called "per-packet updating." In such a process, the dedicated node receives each packet that passes the node and analyzes the packet in order to update corresponding data structures, typically tables. For example, if SNMP is used on an Ethernet and if SNMP is using a RMON-like MIB, the per-packet update would need to update the data structures corresponding to the nine groups.

At some point, the network management tool will likely request this data from the dedicated nodes. For example, it may request this data to display it in graphical form, or it may request this so that it can perform some further data analysis. In any event, SNMP requires that the data be available for external query. The network management tool communicates with the dedicated node, for example by SNMP, by requesting the particular data.

This newer architecture of using dedicated nodes and communication protocols implicitly demands that the dedicated nodes have a very high network performance. Typically the dedicated node needs a network performance an order of magnitude higher than a "normal" node. This is so because the dedicated nodes must be able to process aggregate network traffic, whereas a normal node typically needs to handle bandwidths associated with typical network communications. If a normal node gets congested, it can typically rely upon standard retry algorithms, known in the art, to ensure that it will eventually get the packets intended for it. On the other hand, if the dedicated node gets congested, any missed packet would go unproccessed because when the dedicated node is operating passively and promiscuously it should not request a retry. It will be appreciated that the underlying network protocol defines the process for rejecting and retransmitting packets.

In order to meet these stringent performance requirements, the prior art used dedicated nodes having embedded systems, which relied upon in-line programming for the microprocessors. It was thought that in-line programming was necessary to meet the stringent performance requirements. Essentially, in-line programming is a single stream of code (i.e., program instructions) with no jumps, procedure calls, function calls, or other breaks in the control

of the code. As such, in-line code quickly becomes cumbersome, complex, and difficult for a software engineer to understand.

In the context of network management tools, multiple tables of information in a memory unit usually need to be managed. Often this management contains a certain set of common operations associated with each table and a certain set of unique operations associated with each table. With in-line programming, however, even the common operations must be reiterated at each instance of the management of each table. If a programming bug is present within the common operations, this programming bug will be present at each instance, i.e., for each table. In contrast, if a procedure or function is used for the common operations, the bug will have only one instance.

Moreover, it is highly likely that the code will need to undergo subsequent revisions. In-line programming requires that the programmer decipher the in-line code to discern the exact code fragments that need updating. Similarly to that described above, this update will need to be done at each instance, in contrast to a single instance if procedures and functions are used. This is especially complex in prior art systems as in-line programming is non-modular, and the programmer will have to be wary of protocol sensitive code.

Dynamic module loading, which has been used in other contexts, such as Microsoft Windows' Dynamic Linked Libraries, may be very useful for a dedicated node. For example, such dynamic loading can be helpful for implementing a sophisticated version and release control, in which different network segments can have different combinations of the software. For example, one segment of the network may need a particular application, such as a proxy manager or an accounting package, that the other network segments do not need. Dynamic loading allows the different combinations of software residing on the various segments to be tailored to the system's needs. Dynamic loading also benefits the software distributor, as it will not need to re-link the various software combinations in order to release them (Linking and re-linking software are known in the art). In addition, such loading is also helpful for implementing transient diagnostics. Dynamic loading is extremely difficult to implement with an in-line program technique because the new code will need to be concatenated with the existing code and any new code will need to employ some form of memory address independence (e.g., self-relative addressing) to ensure operability. Though such a process is theoretically possible, the high level of difficulty for doing such a task will be appreciated by those skilled in the art.

All in all, the prior art systems with their use of in-line programming greatly add to development costs and times by requiring more sophisticated programmers to understand the complex, non-modular code.

In connection with this, one can expect that new network management standards will be developed in the future. It is likely that these standards will require more sophisticated statistics and the like. The prior art approach requires that a new in-line program be developed for each new standard. This greatly adds to the development cost and greatly increases the implementation time.

SUMMARY OF THE INVENTION

The shortcomings of the prior art are overcome and other objects are accomplished with a system employing a sufficient number of network nodes connected throughout a computer network adapted to collect network data, wherein each such node has a network interface to translate the electronic signals on the network into a digital form, a memory for storing the digital form, and a CPU for processing the digital form in accordance with software modules stored in the memory, the software modules including a scalable network data engine that is independent of the network protocol of the computer network, and wherein the network data engine is executed by the CPU to provide the functionality for creating and deleting tables within the memory, updating table entries within the tables, inserting and deleting entries from the tables, and searching the tables according to a plurality of indices.

Within this description, reference to the network data engine providing some function is to be understood as the CPU executing the network data engine so as to provide that function.

The network data engine further provides a base set of table functionality and provides a mechanism for calling routines external to the network data engine but residing within the memory. As such, a network application that needs tables need only supply code that is specific to the individuality of each table and need only supply certain information concerning the tables to the network data engine. It will be appreciated that the particular application can correspond to SNMP or to any other application that needs a plurality of tables.

The tables upon which the network data engine operates will likely include the tables required by the network management protocol being used by the network. However, the tables can also include general purpose tables.

As new network standards are developed, the dedicated node utilizing the present invention can be easily updated and ported, as the data engine is independent of the protocol and operates on tables only generally and is not table specific. As such, a new protocol, requiring new tables, can use the network data engine without revision. An implementation of a new protocol need only include new code for each new table's specific individuality.

The present invention provides a mechanism for allowing time based statistics on each table and allows for dynamic loading of modules into the memory of the dedicated node.

BRIEF DESCRIPTION OF THE DRAWING

The invention will become more apparent from the following detailed specification and drawing in which:

FIG. 1 illustrates a network segment;

FIG. 2 illustrates a software module architecture for a dedicated node having the present invention;

FIG. 3 illustrates a preferred embodiment of the software module architecture of the present invention;

FIG. 4 illustrates a software architecture for a RMON MIB;

FIG. 5 illustrates in flow chart form the per-packet update process for a preferred embodiment of the invention;

FIG. 6 is a top level process model of a dedicated node;

FIG. 7 illustrates in flow chart form the periodic updating performed by a preferred embodiment of the invention; and

FIG. 8 illustrates a control structure used by a preferred embodiment of the invention.

DETAILED DESCRIPTION

FIG. 1 illustrates a network section 10 of a computer network. A communication cable 11 interconnects the various network nodes 12. Each network node 12 can typically operate autonomously. However, often these nodes 12 coop-

erate to perform a large task by distributing the work among the various nodes. Though the figure illustrates a network section only, it will be appreciated that such segments can be arranged in various network topologies, such as rings and trees, and that the various segments will likely employ a probe 13. A probe is a network node, dedicated for network management, and is further described below.

In order for one node 12a to communicate with another node 12b, the communication will occur via cable 11. Node 12a will transmit a packet, which will include as a target the address of 12b. Node 12b monitors the cable and detects that the packet is intended for itself by recognizing its address. It will be appreciated that many network protocols allow a broadcast-type communication in which more than one node will receive the communication. It will also be appreciated that the numerous protocols for gaining access to cable 11 as well as for transmitting the network packet are known in the art and that the description above is informational only. These protocols will not be further described herein for the sake of clarity.

In a preferred embodiment, probe 13 utilizes an Intel 80960CA RISC CPU, indicated as 14, 4 MB of memory 15, and the 82596CA LAN interface 16. The several software modules, described below, executed by CPU 14 are written primarily in the C programming language, for example, and may operate under an operating system residing in memory 15 that provides UNIX-like functionality.

Probe 13 operates in a passive and promiscuous mode in which it monitors all packets transmitted on cable 11. The LAN interface 16 translates the electronic signals transmitted on cable 11 into digital form and stores the digital form in memory 15. Then, CPU 14, executing the software modules described below, operates upon this digital form.

Though the description herein refers to the probe as being a dedicated node, it should be appreciated that this is for convenience only. For example, the present invention may be employed in a router and still perform its data collection. Moreover, though the description refers to the probe as receiving all packets passing on the network, it will be appreciated that the present invention is not precluded from an application that operates on a subset of the packets only.

As will be further described below, probe 13 analyzes each packet, i.e., the digital form residing in memory 15, to determine whether the packet is intended for itself. For example, another node may request certain information from probe 13. If a packet is targeted to probe 13, probe 13 will respond accordingly, i.e., like a normal node. If the packet is not intended for probe 13, i.e., the target address is not that of probe 13, probe 13 analyzes the packet in order to update certain tables within memory 15. For example, RMON MIB, a MIB for SNMP, outlines what data should be accessible and how. As such, if the probe 13 is used in an SNMP RMON MIB environment, RMON MIB will determine a minimum set of tables, which probe 13 must keep and manage. As was previously described this process is called per-packet updating and will be further described below.

A network management tool, residing on one or more nodes of the computer network, can then access these tables by communicating certain instructions to probe 13. These instructions are defined by the underlying protocol, e.g., SNMP. As was described above, probe 13 will recognize the packet containing the instruction as intended for itself and respond accordingly.

FIG. 2 illustrates the software module architecture of probe 13. Operating system 21 provides a number of basic operating system functions, such as memory management, event and timing services, process management, I/O services, and numerous device drivers and the like. In a preferred embodiment, operating system 21 is optimized to maximize network packet throughput.

System manager 22 provides a number of ancillary services, such as configuration and module loading, a command line interface, and an interface to serial line access.

The RMON MIB 23 is a management information base. For example, the RMON MIB for the Ethernet has nine groups (see above). Briefly referring to FIG. 4, each group of the MIB may be split into a MIB module 41 and a data collection module 42. The MIB module 41 contains routines and data structures required to represent the corresponding table for the group. The table-specific routines, such as the extract and update routines which are described below, are stored in the data collection module. It will be appreciated that by storing routines in the data collection module the network data engine remains independent of these routines. The process for updating the corresponding tables will be further discussed below. It will be appreciated that different MIB architectures may be utilized by the invention, and for that matter, the invention is not limited to the RMON MIB.

By way of example, SNMP RMON MIB requires a matrix group. This group essentially contains information concerning the numerous conversations occurring on the network segment. It contains data such as the network addresses of the communicating nodes and the associated byte count and packet count between the communicating nodes. Moreover, it organizes this data for each direction of the conversation. The group further specifies that the key for accessing data corresponding to this group is the pair of communicating node addresses. In other words, if an application needed the information described above, it would request that data by requesting data from the Matrix group and by providing a key, comprising the network addresses it was interested in. It will be appreciated that this description of the RMON MIB Matrix group has been simplified for descriptive purposes. Further details about the group are not necessary to understand the present invention.

SNMP module 24 includes the necessary software for communicating in accordance with the SNMP protocol. For example, if SNMP data is requested from the probe, the SNMP module will decode the request. As will be more fully described below, this will include decoding the request into a table name and key which will then be used to retrieve the data from the corresponding table. In addition, SNMP module is responsible for initializing certain aspects of the network data engine 25. As previously stated, network data engine 25 operates on data tables only generally. Thus, SNMP module 24 must pass certain information to network data engine 25 so that network data engine 25 can create the appropriate tables and gather an understanding about the tables for which it is responsible for updating. This is achieved by the SNMP module 24 passing information which will be mirrored in a control structure located within the network data engine 25, in particular within the allocation services (see FIG. 3). This control structure is created dynamically. Each table will have its own control structure. Moreover, each table is created dynamically by the data engine 25 and is "owned" by the data engine.

Even though FIG. 2 illustrates module 24 as an SNMP module, it will be appreciated that this module can be replaced by any application that needs to manage tables. For example, if a new network management protocol were developed, the new application would replace SNMP 24 and would need to pass the necessary data to network data

engine 25 so that data engine 25 could construct the appropriate control structure.

It will be appreciated that, though the following description uses the terms "structure" and "function" in similar fashion to that of the C programming language, other languages employ different terminology to describe similar facilities and that the present invention is in no way limited to a particular programming language.

Referring to FIG. 8, each table has a control structure 80 that includes the following: the maximum number of rows to allow for the table 81; the size of each row 82; the offset from the base of the row to a hash key 83; the size of the hash key; the number of slots in the hash table 85; a pointer 86 to the base of a hash table 87; an array of directory descriptors 90; an array of per-packet update structures 91, which are described below; a pointer 92 to a first stage hash function 92; and pointer 94 to an init function 95.

Each per-packet update structure 91A includes an extract function 96 and an update function 97. These functions will be further described below. Other items included in the control structure will be described below.

Each control structure 80 includes an array of directory descriptors 90, as stated above. A directory 98 is a group of additional indices sorted according to a key. Accordingly, every time an entry is added or deleted from the associated table, the directory needs to be resorted. As was discussed above in the summary of the invention, the particular application may require one or more directories for a group. For example, in the Matrix group, two directories are needed. The key will be the pair of addresses, and there will be one directory corresponding to each direction of communication. Again, the use of directories will depend upon the underlying application.

As previously mentioned, network data engine 25 is responsible for updating the various tables on a per-packet basis. FIG. 3 illustrates the software structure of network data engine 25. FIG. 5 shows a flow chart describing the per-packet update process. The network data engine 25 will be described by referring to these figures jointly.

Packet input section 32 receives all network packets that pass probe 13 (see also 51, FIG. 5). These packets are then passed to data engine core 1. Upon receiving a packet, data engine core 31 loops through each table that is marked "active" (i.e., tables may be suspended from per-packet updating). For each active table, the data engine core 31 loops through the array of per-packet update structures 91 (see also 53, FIG. 5).

Within the loop, i.e., the loop corresponding to the per-packet update structures, the network data engine extracts a key from the packet by calling the extract function 96 pointed to by the per-packet update structure 91A (see also 54, FIG. 5).

If the extract function fails to find a key, for example because the packet is too short or because the packet is corrupt, the data engine core 31 aborts this update and proceeds to the next per packet update (see also 55, FIG. 5). If a key is found, the data engine core 31 calls a first stage hash function 93 pointed to by the control structure 80 (see also 56, FIG. 5). This hash function 93 preferably is matched to the nature of the data that is stored within that table. Hash functions desirably provide an even distribution of hash numbers given a distribution of keys. A second stage of hashing is performed by the network data engine itself to insure that the resulting address will fall within the corresponding table (see also 57, FIG. 5).

The network data engine core 31 will perform necessary table management, such as inserting a new entry if necessary (see also 58, FIG. 5). In addition, it will also perform collision handling, for example if two keys hash to the same table entry (see also 58, FIG. 5). Collision handling and table management are known in the art.

The network data engine core 31 also calls an init function 95 pointed to by the control structure 80 whenever a new table entry is created, i.e., whenever it is the first instance of a key (see also 59, FIG. 5). If the packet had error status it is likely that the application would prefer to not process that packet. The init function 95 would then include the appropriate code to abort further processing for this table.

Lastly, the core 31 also calls an update function pointed to by the per-packet update structure 91A (see also 60, FIG. 5). This function usually contains the "guts" of per-packet updating. Again, this function, like those described above is application specific, and the data engine 25 remains independent of it.

It will be appreciated that this process is independent of the underlying protocol, e.g., SNMP, as the control loop operates on the various tables only generally and calls external routines to handle the peculiar aspects of the particular table.

The upcall interface 33 handles the external function calling, referred to above. The allocation services 35 allows the creation and deletion of network data engine tables, and the ability to activate or suspend existing tables. Tables are usually created at initialization and can be deleted, if necessary.

Table access and manipulation services 34 allow the underlying application, e.g., the SNMP application, to access the data that is being collected. Each table can be accessed using any one of its indices. This section is also responsible for table entry insertion and deletion as requested by the associated application, i.e., SNMP. The indices automatically recalculate after each insert and delete operation. For example, an insertion will occur when the probe receives a packet from a node for the first time.

Data entry core 31 provides synchronization for the tables. This is necessary because the tables need read and write access from multiple sources, such as during per packet updates and from SNMP requests. Synchronization methods are know in the art, and will not be further discussed herein other than to state that, in a preferred embodiment, the network data engine 25 operates at a process level higher than the associated application, i.e., SNMP.

Since network data engine 25 is independent of the particular protocol, the functions for operating on the various tables are independent of the protocol, as well. As such, the network data engine 25 can be used for general purpose tables used by the various software modules. Moreover, network data engine 25 is easily ported to future protocols and different revisions of an existing protocol, which will require different tables.

FIG. 6 illustrates the various software mechanisms of probe 13, displayed as a top level process model. Some abstraction is present for the sake of clarity. This is an alternative way of describing the software architecture. The several software processes correspond to the several modules previously discussed, with minor variations. LAN process 64 handles the network interface. Every time LAN process 64 receives a packet it calls network data engine 25 and passes the corresponding packet with associated status to the network data engine 25. The network data engine 25 is embedded within the LAN process 64, and both operate at Kernel priority level, in a preferred embodiment.

The network data engine then operates as described above. Probe **13** operates in a promiscuous mode, listening to all traffic passing the probe. However, it also receives and transmits packets in similar fashion to other network nodes. If a packet is addressed to the probe, i.e., the target address of the packet corresponds to the probe address, LAN process **64** passes the packet to network process **65**, assuming that there are no errors. Network process **65** then either passes the packet up through the various network protocol layers or rejects the packet. For example, if the packet is SNMP related the packet will be passed to SNMP process **66**. SNMP process operates at a priority level lower than the LAN process **64**, in a preferred embodiment. This process is similar to other network processes known in the art.

Processes **66–68** are similar to the corresponding modules discussed in relation to FIG. **2**, and their description will not be repeated herein for the sake of clarity.

The process model illustrated in FIG. **6** is helpful for describing the dynamic software environment of probe **13**. This environment allows a dynamic loading of modules. As such, a dynamically loadable module ("DLM") **69** can be transmitted to probe **13**, via known file transfer protocols. As such, operating system **21** (see also FIG. **2**) will manage DLM **69** in addition to the processes already discussed. It is loaded by system manager **69**, as previously stated. This dynamic loading of processes is known within the computer field, but has primarily been used in different contexts. For example, Microsoft allows dynamic loading via its Dynamic Linked Library and UNIX allows such loading via its "Shared Library" utility. Previously, this was impractical for prior art dedicated nodes.

Moreover, the process model displayed in FIG. **6** makes is easier to understand the network data engine in relation to the operating system and the other processes. For example, the present invention can perform table updates periodically. Periodic updates can be performed by calling the appropriate update functions in a timed fashion. Consequently, time-based statistics can be easily implemented. For example, response times for packets can be determined by time-stamping when a request was sent out and noticing when a response was received. It is important to note that SNMP does not suggest or require such statistics.

In order to perform such time-based statistics, the control structure **80** (See FIG. **8**) described above also includes a record number index **88** which in effect is an insertion order index. This points to all the valid table entries, but does not require the overhead of using keys. Thus, it provides for faster response in bulk-type transactions.

The control structure also includes an array of rank descriptors **99**, a rank **100** being a table of indices sorted by a particular key and updated periodically. As such, they are somewhat akin to directories, but again, directories are updated on insertion and deletion of entries. The control structure **80** also points **101** to a periodic update function **102** that is called once per time interval for each row in the table. In a preferred embodiment, the time interval is one second. The network data engine **25** then loops through each active table and calls the periodic update function for each valid table entry pointed to by the record number index. It will be appreciated that this process allows the underlying application to calculate time-based statistics or to trigger some other time-based activity.

FIG. **7** illustrates a flow chart describing the periodic update process. Referring to FIG. **7** and **8** jointly, at every time interval **71** the network data engine will loop through each table determining whether the table is marked active **72** (See also **99**, FIG. **8**). If the table is marked active the network engine determines whether a periodic update function (See also **102**, FIG. **8**) is present for that table **73**. Then, for each row pointed to by the record number index (See **89**, FIG. **8**), which in turn is pointed to by the control structure **74**, the network data engine calls the periodic update function pointed to by the control structure **75**. This periodic update function is passed the time delta **103** since the last update in addition to a pointer to the table entry, so that the function can perform accurate time-based statistics. This time delta is necessary to compensate for inaccuracies that might otherwise occur as a result of new table entries, etc.

Having thus described several particular embodiments of the inventions, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements as are made obvious by this disclosure are intended to be part of this disclosure though not exclusively stated herein, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only and is not intended to be limiting. The invention is limited only as to find the following claims and equivalents thereto.

What is claimed is:

1. A method of collecting network data from a computer network at a remote node having a processor, an operating system, a network protocol module for communicating on the network in accordance with a predefined protocol, a management information base arranged in accordance with the protocol and having tables for storing the collected data and having corresponding functions for each table including a periodic update function and a network data engine, the method comprising the steps of:

(a) the network protocol module providing a description of the management information base to the network data engine, including providing a description of the tables and providing a pointer to the corresponding periodic update function;

(b) the network data engine receiving the description and constructing therefrom a control structure for each table;

(c) after step (b), the network protocol module monitoring the network and reciveing all packets passing therethrough;

(d) upon receiving a packet, the network protocol module passing the packet to the network data engine;

(e) the network data engine processing the packet in accordance with the control structure for each table;

(f) at predetermined intervals, the network data engine calling the periodic update function for each table to update the table in accordance therewith; and

(g) the network protocol module providing a record number index pointing to an index, the index having indices listed in the order of insertion of table entries of the tables.

2. A method of collecting network data from a computer network at a remote node having a processor, and operating system, a network protocol module for communicating on the network in accordance with predefined protocol, a management information base arranged in accordance with the protocol and having tables for storing the collected data and having corresponding functions for each table, including a periodic update function, and a network data engine, the method comprising the step of:

(a) the network protocol module providing a description of the management information base to the network

data engine, including providing a description of the tables and providing a pointer to the corresponding periodic update function;

(b) the network data engine receiving the description and constructing therefrom a control structure for each table;

(c) after step (b), the network protocol module monitoring the network and receiving all packets passing therethrough;

(d) upon receiving a packet, the network protocol module passing the packet to the network data engine;

(e) the network data engine processing the packet in accordance with the control structure for each table;

(f) at predetermined intervals, the network data engine calling the periodic update function for each table to update the table in accordance therewith; and

(g) the network protocol module providing an array of rank descriptors, cash rank descriptor pointing to a rank, a rank being a table of indices sorted by a corresponding key, and wherein step (f) updates the table via a rank.

3. A method for collecting network data from a computerized network, the method comprising the steps of:

(a) creating, for a plurality of groups of data intended to be collected from the network, a respectively corresponding plurality of control structures;

(b) associating the plurality of control structures with a respectively corresponding plurality of tables, the plurality of tables being adapted to store the plurality of groups of data; and

(c) storing, for each one of the plurality of control structures, in an associated one of the plurality of tables, a respectively corresponding one of the plurality of groups of data based on a network packet received from the computerized network,

wherein a first set of control structures of the plurality of control structures is associated with a first management information base defining a first set of groups of data of the plurality of groups of data, and wherein step (c) includes a step of:

calling, for each one of the first set of control structures, functions of the first management information base to update a first set of tables of the plurality of tables,

and wherein a second set of control structures of the plurality of control structures is associated with a second management information base defining a second set of groups of data different from the first set of groups of data, and wherein step (c) further includes a step of:

calling, for each one of the second set of control structures, functions of the second management information base to update a second set of tables of the plurality of tables,

and wherein the functions include a first extract function and a first update function, wherein the first set of tables includes a first table, and wherein the step of calling includes a step of:

invoking the first extract function to extract a first key from the network packet, and the first update function to update the first table according to the first key,

and wherein the functions further include a second extract function and a second update function, wherein the first set of tables further includes a second table, and wherein the step of calling further includes a step of:

invoking the second extract function to extract a second key from the network packet, and the second update function to update the second table according to the second key.

4. The method of claim 3, wherein the step of calling further includes a step of:

invoking the second extract function to extract a second key from the network packet, and the second update function to update the first table according to the second key.

5. The method of claim 3, wherein the first table includes a plurality of rows respectively identified by a plurality of keys, and wherein the step of invoking includes a step of:

updating one of the plurality of rows respectively identified by the first key.

6. The method of claim 5, wherein the step of calling further includes a step of:

invoking, when initially none of the plurality of rows is respectively identified by the first key, a create function to insert and initialize a new row respectively identified by the first key, in the plurality of rows of the first table.

7. The method of claim 3, further comprising a step of:

accessing at least one of the plurality of tables to retrieve at least one of the plurality of groups of data.

8. The method of claim 7, wherein the plurality of tables are sorted in a first order and a second order, and wherein the step of accessing includes a step of:

retrieving the at least one of the plurality of groups of data in the first order in response to a first command, and in the second order in response to a second command.

9. The method of claim 3, further comprising a step of:

periodically storing, for a periodic structure respectively corresponding to a periodic table, time based statistics of the computerized network.

10. The method of claim 3, wherein the plurality of control structures is arranged as a linked list of control structures, and wherein step (a) includes a step of inserting a control structure into the linked list.

11. The method of claim 3, wherein the plurality of control structures is arranged as an array of control structures, and wherein stop (a) includes a step of adding a control structure to an end of the array.

12. A system for collecting network data from a plurality of groups of data in a computer network through which network packets flow, comprising:

a plurality of control structures, each control structure corresponding to a group of data from the plurality of groups of data; and

a plurality of tables associated with the plurality of control structures, the plurality of tables being adapted to store the plurality of groups of data;

wherein for each one of the plurality of control structures a respectively corresponding one of the plurality of groups of data based on the network packet received from the computerized network is stored in an associated one of the plurality of tables, and

wherein a first set of control structures of the plurality of control structures is associated with a first management information base defining a first set of groups of data of the plurality of groups of data, and wherein for each one of the first set of control structures, functions of the first management information base are called to update a first set of tables of the plurality of tables, and

wherein a second set of control structures of the plurality of control structures is associated with a second management information base defining a second set of groups of data different from the first set of groups of data, and wherein for each one of the second set of control structures, functions of the second management

information base are called to update a second set of tables of the plurality of tables, and

wherein the functions of the first management information base include a first extract function and a first update function, wherein the first set of tables includes a first table, and wherein function calling includes invoking the first extract function to extract a first key from the network packet, and the first update function to update the first table according to the first key, and

wherein the functions of the second management information base include a second extract function and a second update function, wherein the first set of tables further includes a second table, and wherein calling further includes invoking the second extract function to extract a second key from the network packet, and the second update function to update the second table according to the second key.

13. The data collection system of claim **12** wherein function calling includes invoking the second extract function to extract a second key from the network packet, and the second update function to update the first table according to the second key.

14. The data collection system of claim **12** wherein the first table includes a plurality of rows respectively identified by a plurality of keys, and wherein invoking the extract function includes updating one of the plurality of rows respectively identified by the first key.

15. The data collection system of claim **14**, wherein function calling includes invoking a create function when initially none of the plurality of rows is respectively identified by the first key to insert and initialize a new row respectively identified by the first key in the plurality of rows of the first table.

16. The data collection system of claim **12** wherein at least one of the plurality of tables is accessed to retrieve at least one of the plurality of groups of data.

17. The data collection system of claim **16** wherein the plurality of tables are sorted in at least first and second orders, and wherein at least one of the plurality of groups of data in the first order is retrieved in response to a first command, and at least one of the plurality of groups of data in the second order is retrieved in response to a second command.

18. The data collection system of claim **12** wherein time based statistics of the computerized network are periodically stored.

19. The data collection system of claim **12** wherein the plurality of control structures is arranged as a linked list of control structures, and wherein a control structure is inserted into the linked list.

20. The data collection system of claim **12** wherein the plurality of control structures is arranged as an array of control structures, and wherein a control structure is added to an end of the array.

* * * * *

US005630122A

United States Patent [19]

Kaplan et al.

[11] **Patent Number: 5,630,122**

[45] **Date of Patent: *May 13, 1997**

[54] **COMPUTERIZED REPORT-BASED INTERACTIVE DATABASE QUERY INTERFACE**

[75] Inventors: **Craig A. Kaplan**, Santa Cruz; **Stanley E. Taylor**, San Jose; **Gregory J. Wolff**, Mountain View, all of Calif.

[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,426,781.

[21] Appl. No.: **398,583**

[22] Filed: **Mar. 2, 1995**

Related U.S. Application Data

[63] Continuation of Ser. No. 876,255, Apr. 30, 1992, Pat. No. 5,426,781.

[51] **Int. Cl.**^{6} **G06F 17/30**

[52] **U.S. Cl.** **395/604**; 395/613; 364/DIG. 1

[58] **Field of Search** 395/600, 155, 395/161, 604, 613

[56] **References Cited**

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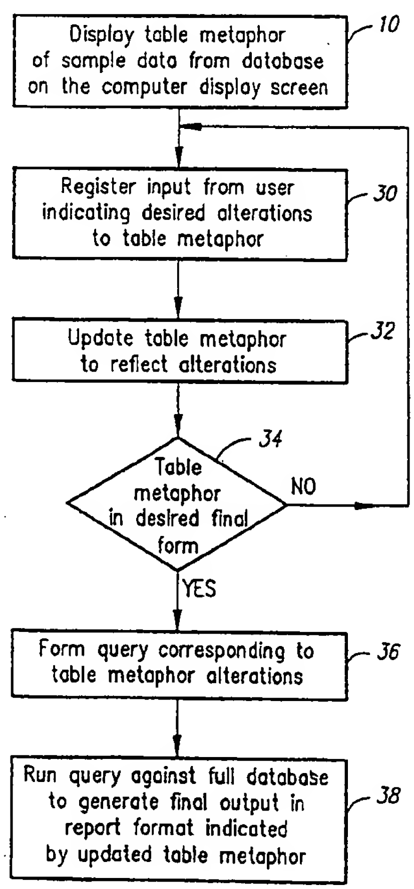
Primary Examiner—Thomas G. Black
Assistant Examiner—John C. Loomis
Attorney, Agent, or Firm—Marilyn Smith Dawkins

[57] **ABSTRACT**

In a computer database system, a method and system are provided for interactively and iteratively constructing a query using a table metaphor displayed on a user display. Alterations are made directly to the table metaphor by the database user. The alterations relate to adding, deleting, or combining columns of attributes and limiting ranges of attribute values. The alterations are registered and the table metaphor updated to reflect the registered alterations. The table metaphor can be repeatedly used to further register additional alterations. The query corresponding to the table metaphor in its final form is run against the full database to generate a report in the format indicated by the table metaphor.

2 Claims, 5 Drawing Sheets



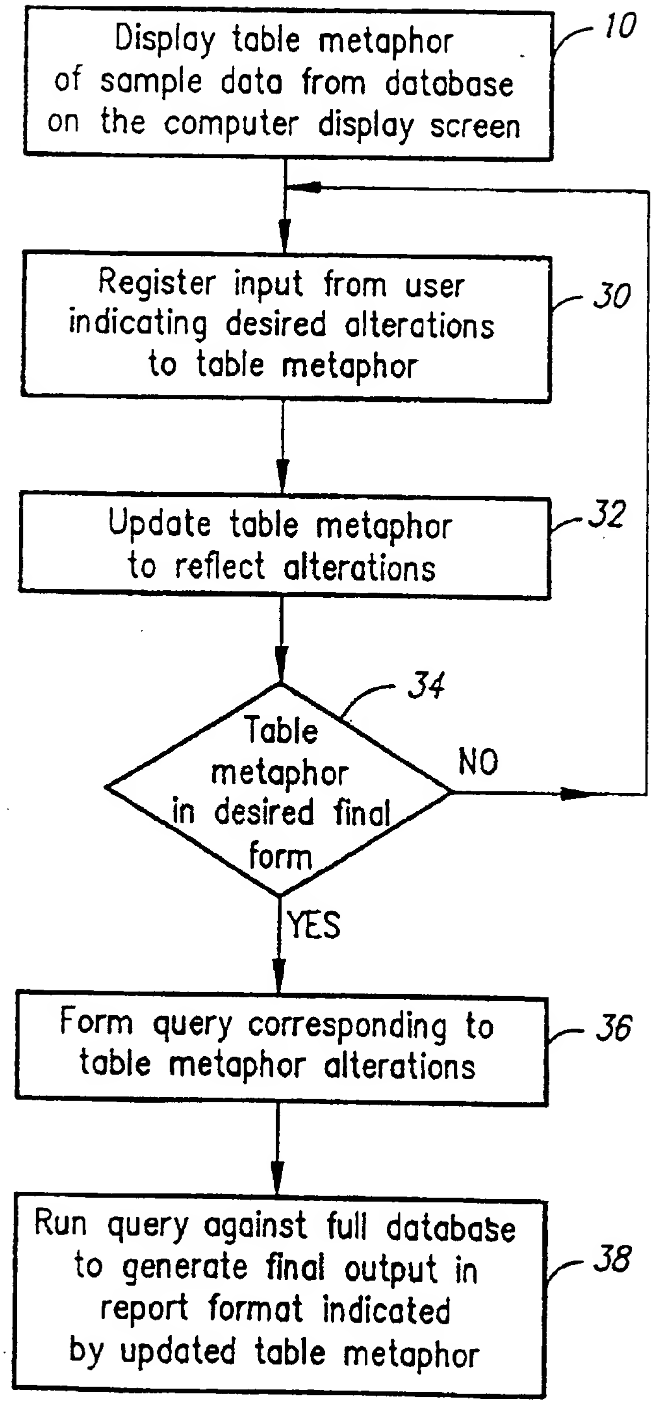

Display table metaphor of sample data from database on the computer display screen
10
Register input from user indicating desired alterations to table metaphor
30
Update table metaphor to reflect alterations
32
34
Table metaphor in desired final form
NO
YES
Form query corresponding to table metaphor alterations
36
Run query against full database to generate final output in report format indicated by updated table metaphor
38

FIG. 1

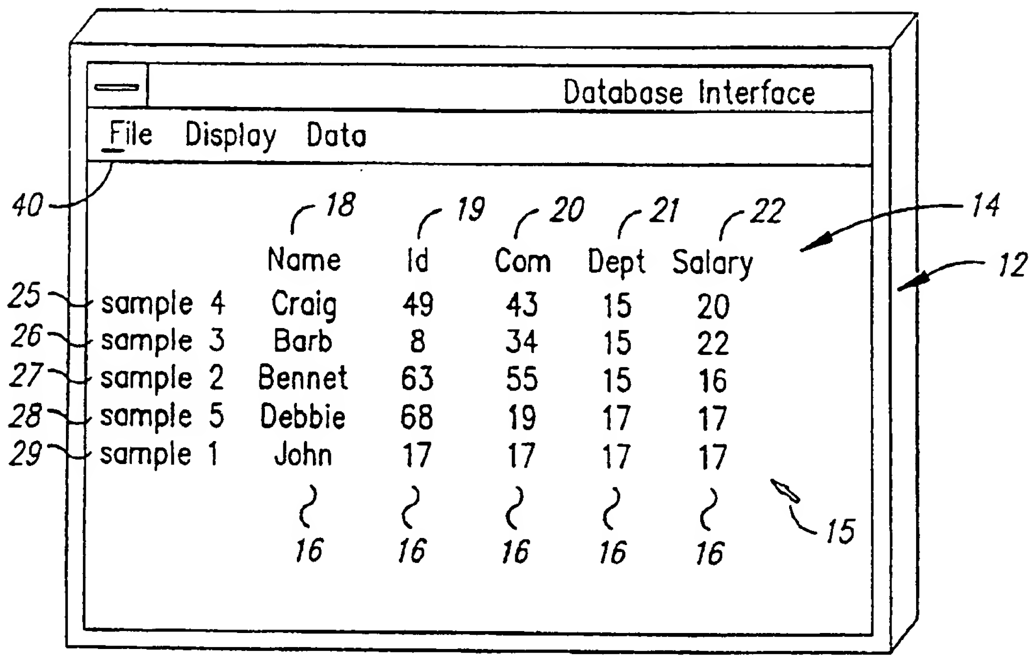

Database Interface
File Display Data
40
18 19 20 21 22
14
Name Id Com Dept Salary
12
25 sample 4 Craig 49 43 15 20
26 sample 3 Barb 8 34 15 22
27 sample 2 Bennet 63 55 15 16
28 sample 5 Debbie 68 19 17 17
29 sample 1 John 17 17 17 17
15
16 16 16 16 16

FIG. 2

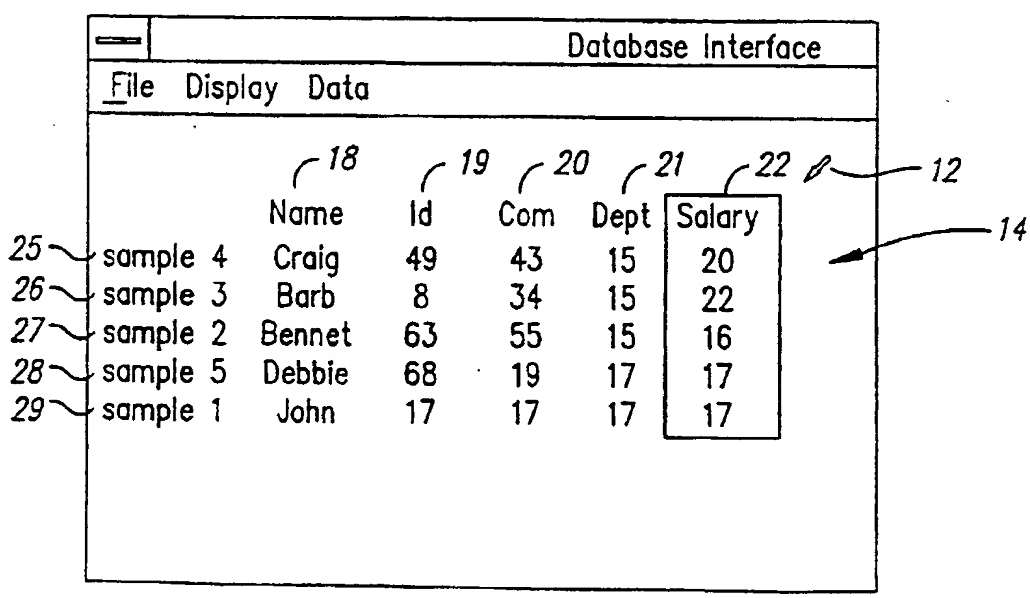

Database Interface
File Display Data
18 19 20 21 22
12
Name Id Com Dept Salary
14
25 sample 4 Craig 49 43 15 20
26 sample 3 Barb 8 34 15 22
27 sample 2 Bennet 63 55 15 16
28 sample 5 Debbie 68 19 17 17
29 sample 1 John 17 17 17 17

FIG. 3

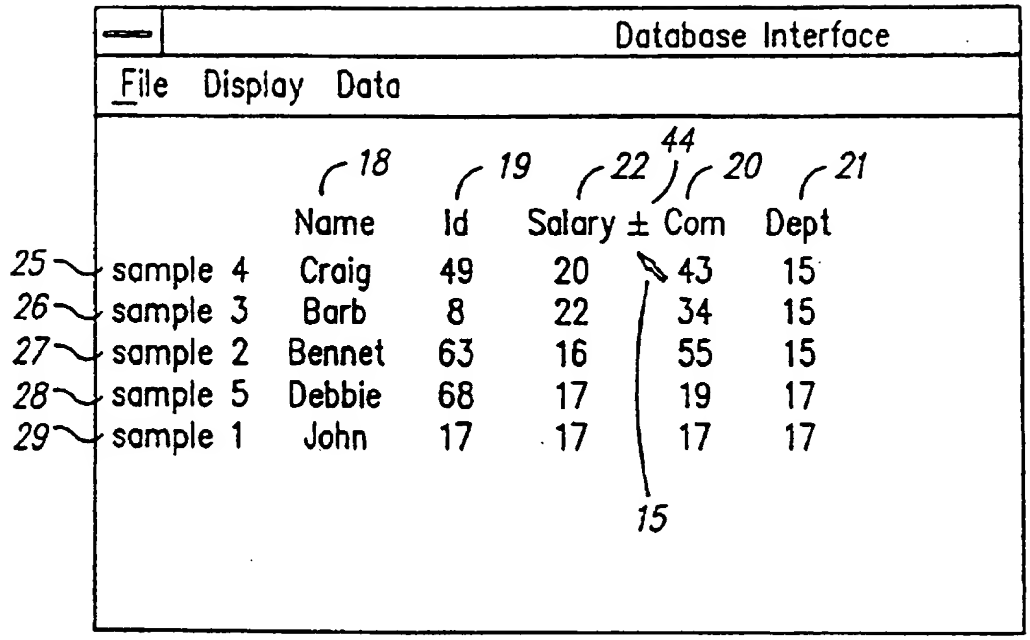

Database Interface
File Display Data
18 19 22 44 20 21
Name Id Salary ± Com Dept
25 sample 4 Craig 49 20 43 15
26 sample 3 Barb 8 22 34 15
27 sample 2 Bennet 63 16 55 15
28 sample 5 Debbie 68 17 19 17
29 sample 1 John 17 17 17 17
15

FIG. 4

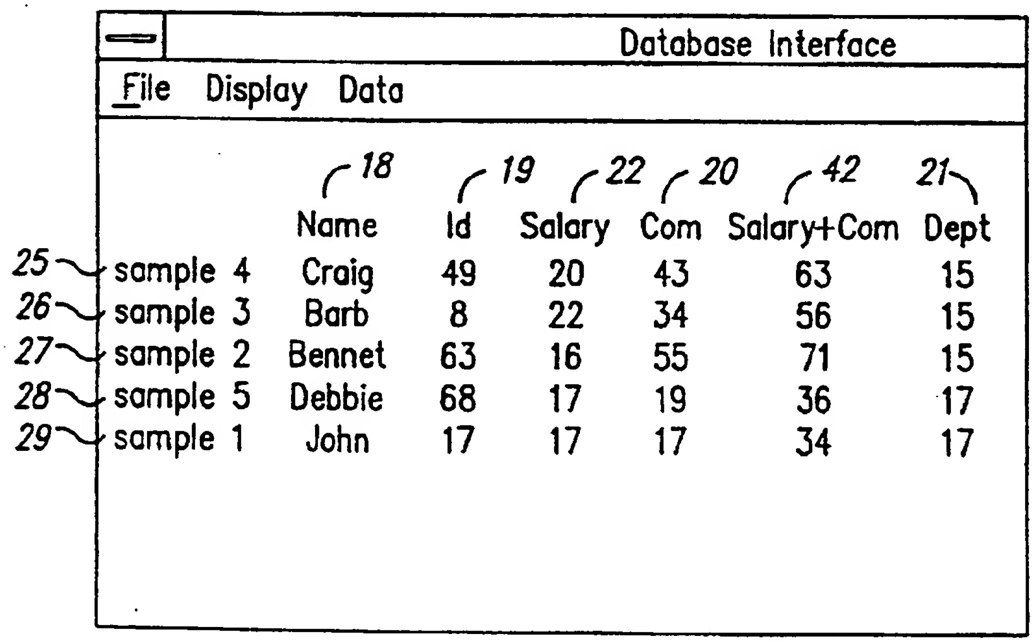

Database Interface
File Display Data
18 19 22 20 42 21
Name Id Salary Com Salary+Com Dept
25 sample 4 Craig 49 20 43 63 15
26 sample 3 Barb 8 22 34 56 15
27 sample 2 Bennet 63 16 55 71 15
28 sample 5 Debbie 68 17 19 36 17
29 sample 1 John 17 17 17 34 17

FIG. 5

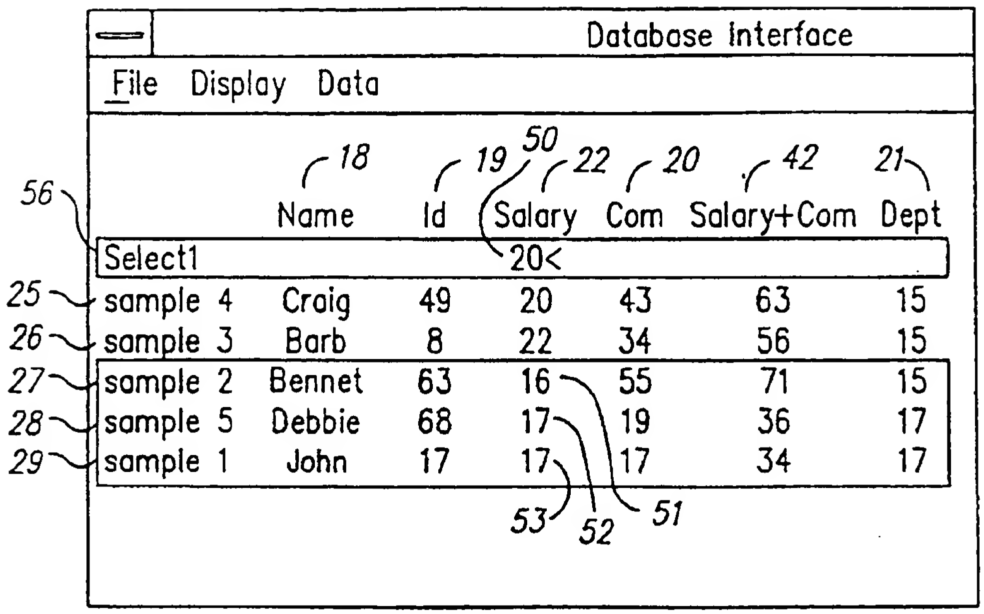

Database Interface
File Display Data
18
19
50
22
20
42
21
56
Name Id Salary Com Salary+Com Dept
Select1 20<
25
26
27
28
29
sample 4 Craig 49 20 43 63 15
sample 3 Barb 8 22 34 56 15
sample 2 Bennet 63 16 55 71 15
sample 5 Debbie 68 17 19 36 17
sample 1 John 17 17 17 34 17
53
52
51

FIG. 6

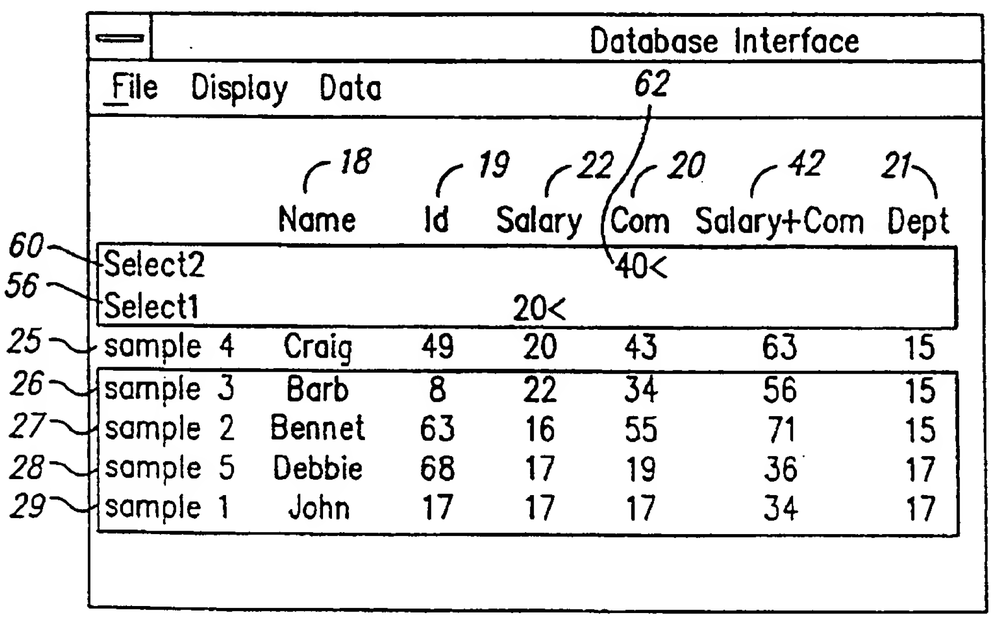

Database Interface
File Display Data
62
18
19
22
20
42
21
Name Id Salary Com Salary+Com Dept
60
56
Select2 40<
Select1 20<
25
26
27
28
29
sample 4 Craig 49 20 43 63 15
sample 3 Barb 8 22 34 56 15
sample 2 Bennet 63 16 55 71 15
sample 5 Debbie 68 17 19 36 17
sample 1 John 17 17 17 34 17

FIG. 7

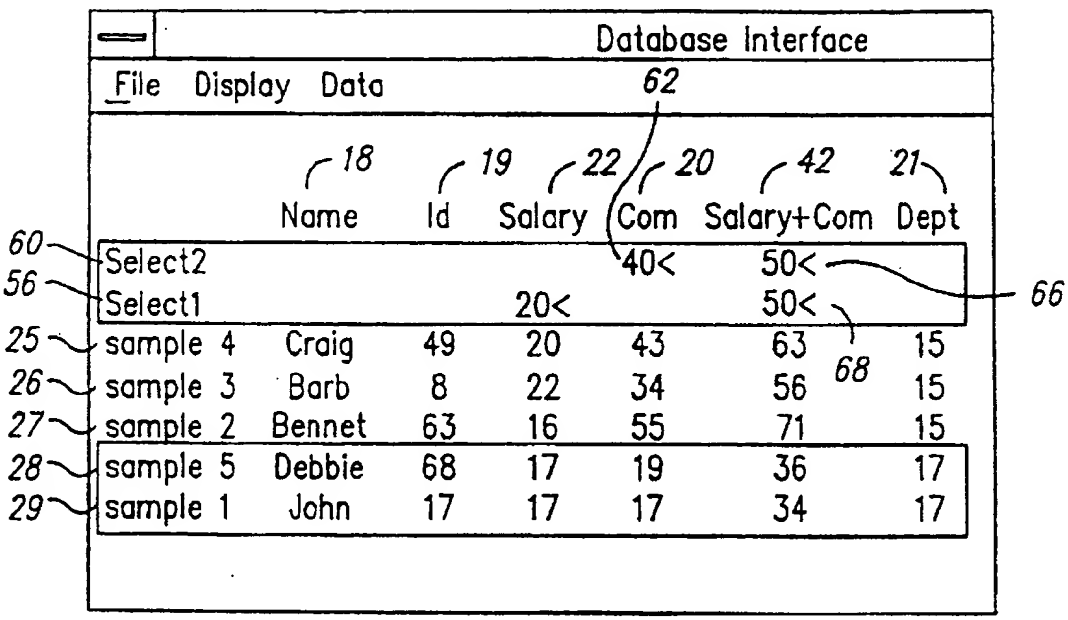

Database Interface
File Display Data
62
18
19
22
20
42
21
Name Id Salary Com Salary+Com Dept
60
Select2 40< 50<
66
56
Select1 20< 50<
25
sample 4 Craig 49 20 43 63 15
68
26
sample 3 Barb 8 22 34 56 15
27
sample 2 Bennet 63 16 55 71 15
28
sample 5 Debbie 68 17 19 36 17
29
sample 1 John 17 17 17 34 17

FIG. 8

COMPUTERIZED REPORT-BASED INTERACTIVE DATABASE QUERY INTERFACE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. Pat. No. 5,426,781, filed on Apr. 30, 1992, entitled "COMPUTERIZED REPORT—BASED INTERACTIVE DATABASE QUERY INTERFACE" in the name of Craig A. Kaplan, et al.

TECHNICAL FIELD

This invention relates to computerized database systems. More particularly, this invention relates to an interactive interface for graphically formulating a relational database query and simultaneously formulating a report format to display the results of the query.

BACKGROUND OF THE INVENTION

Computer databases that store data electronically are commonly used for retrieving data more efficiently and easily than paper file storage methods. Database systems can be used to produce reports organizing the data for output to the user in clear formats. For example, an employee database can contain data on employees such as their respective names, salaries, departments, managers, and employee IDs. This information can be periodically retrieved and organized into reports, such as a report on all employees having salaries in a given salary range. The report could specify, for those employees having a salary in a given range, their names, employee IDs and departments. Similarly, a report can be produced on every employee in a given department, containing their names and employee ID.

One type of computer software database management system for logically organizing the data stored in the database is a relational database management system (RDBMS). In a RDBMS, the data is logically stored in tables having columns corresponding to attributes of the data (such as employee ID, salary, and department number) and rows corresponding to the records of grouped attributes (such as the attributes for a given employee). Query languages such as the structured query language (SQL) are used to query the database and extract particular portions of the data, such as a list of particular attributes of employees having a certain range of salary, as described above.

In order to generate the report, a database user has to be familiar with the commands and syntax of the query language used by a given database. This can require special training and expertise to write queries to generate reports. The user, interested in creating a report, is side-tracked first into learning this special language to find the data for the report. For example, there is a need to know the logic used by the query language, which can be counter-intuitive. If a user were to try to determine all employees who live in Oklahoma and Kentucky, the user would intuitively want to generate a query command asking for users in "Oklahoma and Kentucky." However, there is a difference between the 'and' as used in common English language and the logical AND operator used in query languages. In order to determine all employees who live in two different states, a logical OR has to be used to identify those employees that are residents of the first state or the second state. The AND operator would be used when trying to identify employees that are residents of both Oklahoma and Kentucky.

When working on a report layout and desired content, the database user often needs to make modifications to the report after reviewing the generated report. However, in most query languages, a simple modification to a report content or layout can require completely rewriting a new query statement. This query statement has to be run against the entire database to produce the updated report to be reviewed. This requires a lot of time from the user and from the computer system in which the database system is stored and the RDBMS is run. It would be better to be able to allow the database user to directly manipulate the report and immediately see the results of the alterations.

There are a number of query interfaces that simplify the query generation process, such as Query-By-Example (QBE) as described by M. M. Zloof, "Query-by-Example: a data base language", IBM System Journal, Vol 16, No. 4, 1977, pp. 324 ff. There are query building interfaces which simplify query writing by taking advantage of workstation based graphical user interfaces. While the current graphical interfaces make it easier to formulate queries, there is still a need for making the process even easier. Also, there is a need to improve the process of generating reports by allowing a user to formulate a query and design the report format at the same time. Particularly since people who work in a business environment are familiar with reports and since the goal in querying a database is to produce a report, it would be desirable to provide a graphical query interface which allows for direct manipulation of a report and for immediate feedback of how the database report format would appear.

SUMMARY OF THE INVENTION

A method is provided for interactively formulating a query and a report format simultaneously using data contained in the database stored in a computer system having a processor, memory, data storage and a display terminal. A table metaphor is displayed on the display terminal where the table metaphor corresponds to a subset of the database data. Alterations to the table metaphor made directly by a user are registered by the computer. An updated version of the table metaphor reflecting the direct alterations is displayed on the display terminal. Further alterations are registered and updated table metaphors are displayed a plurality of times until a final table metaphor is produced. A final query is produced reflecting the final table metaphor. The final query is run against the entire database to produce query output that is formatted according to the table metaphor.

One of the alterations can be a change to the report format, such as movement of the columns of the report. One way of indicating the movement of the columns is for the user to graphically move the columns using a mouse or other interactive device to click the mouse button after the mouse has been used to position the display screen cursor on a column, have the column become highlighted, then drag the highlighted column to a new location and then unclick the depressed mouse button.

Another registered alteration can be the generation of a new column based on other columns of the table. One way to generate a new column is to allow a user to place an operator between two adjacent columns. The new column generated contains respective attributes of the adjacent columns combined by the operator.

Other alterations of the table metaphor are placement of range limitations on attribute values for the report output and the combination of these attribute range limitations using AND and OR operations. One method of placing range limitations is to allow a user to indicate a cell of the table metaphor, display a select row, and then input a range

limitation value and operator in the select row in the cell parallel to the selected cell. Entering more than one value and operator on the same select line has the effect of an AND operation requiring the query response have attribute values within both respective ranges. If the user selects another cell in the table metaphor, another select row is displayed. A plurality of select rows have the effect of an OR operation, where records (table metaphor rows) that satisfy the query satisfy all the respective range conditions of any select row. The table metaphor rows satisfying the query are highlighted for the user to identify which rows are part of the final output.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flowchart of the preferred embodiment of the invention;

FIG. 2 is an example of a table metaphor; and

FIGS. 3–8 illustrate alterations of the table metaphor of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, the preferred embodiment of the invention provides for displaying a table metaphor on a display screen 10, such as table 14 on display screen 12 shown in FIG. 2 of sample data from a database. The database is stored in a computer system having memory, a processor, a display screen, external storage such as a disk drive, and interaction means, such as a mouse and keyboard, for enabling a user to interact with the system. The interaction means can comprise positioning means for a user to position a cursor 15 on the display screen and execution means for the user to signal the system. An example of positioning means and, execution means is a mouse, having means for allowing a user to interactively control the position of the display screen cursor 15, and an associated button which can be depressed to signal the system. There are other such devices known to those skilled in the art for interacting with a computer system which can be used with this invention.

The database from which the table metaphor 14 shown in FIG. 2 is a subset contains information on employees. The table metaphor 14 has columns 16 containing attribute values for the employee name (Name) 18, the employee ID (Id) 19, the commission earned by the employee (Com) 20, the department (Dept) 21 of the. employee, and the salary (Salary) 22 of the employee. The table metaphor 14 contains sample data rows 25–29 corresponding to five of the employees from the full database. The sample data used in the table metaphor is reflective of the range of attribute values in the database. The table metaphor can be a table of the database or preprocessing can be performed to provide a table that is some combination of database tables.

The table metaphor 14 is used as a worksheet to determine the final format of the report, such as which attributes would be included and the range of the attributes corresponding to the data to be retrieved. Referring again to FIG. 1, input from the user is registered by the system 30. The input indicates to the system the user's desired alterations to the table metaphor 14. The system processes the input and generates an updated table metaphor reflecting the alterations made by the user 32. The system can also generate the query statements used to generate the output as indicated by the user's alteration. These can be displayed to the user as a tutorial or as further explanation for the alterations entered by the user.

The user can continue to alter and update the table metaphor and have displayed on the display screen 12 the results of the alterations, until the user is satisfied with the results of table format and content 34. The system then generates a query statement corresponding to the final table metaphor 36. This query can be run against the entire database to generate a final output in the desired report format 38.

The foregoing procedure allows a user to generate queries without requiring knowledge of query languages. The queries can be constructed and refined iteratively before executing the query on the entire database. The iterative construction using sample data reduces the load on a shared centralized database system. Additionally, reports are formatted at the same time that the queries are constructed, thus eliminating a step in the normal process of producing reports.

There are various alteration that a user can input to indicate the format and contents of the final report. One of the alterations that can be input can relate to changing the placement of the columns of the report, deleting columns, or creating new columns by performing an operation on attribute values of existing columns. Other alterations of the table metaphor that can be input can relate to placing range limitations on attribute values for the report output and to combine these attribute range limitations using AND and OR operations.

The alterations are conveyed to the system using interactive graphic devices such as a computer mouse or keyboard. The user controls the placement of the cursor 15 and signals the system. The location of the cursor in relation to the table metaphor when the system is signalled indicates to the system the further prompts to be provided in order to register further input from the user. The user also interacts with the system using menu 40 sequences prompting input.

FIGS. 3–8 illustrate some examples of the direct alterations to the table metaphor 14. Referring to FIGS. 3 and 4, one alteration of the table metaphor can pertain to rearranging columns in the final report. For example, the user may want to move the salary column 22 closer to the commission column 20 so that it is easier to read the final report. In most database systems, the query language would provide a formatting statement to indicate how the report should appear. However, it is more productive to allow the user to see the results of rearranging columns, while still formatting and constructing the report.

In a preferred embodiment of the invention, an interactive device, such as a mouse, is used to move the cursor 15 over to the salary column 22. The user signals the system by clicking at that location (depressing the mouse button). The salary column 22 then becomes highlighted as shown in FIG. 3. While the user is depressing the mouse button, the salary column is dragged to a new location. When the salary column is at the desired location, the mouse button is released and the salary column 22 is positioned in its new location as shown in FIG. 4. There are numerous other ways of moving the columns as are well-known to those skilled in the art. A column can also be removed by indicating that a column is to be deleted using any one of a number of methods known to those skilled in the art.

Another alteration that can be input by the user pertains to adding a new column based on existing columns. Referring to FIG. 5, a new column 42 of salary plus commission has been added next to the commission column 20. The attribute values in the new column 42 are the respective salary and commission attribute values of the respective employees in rows 25–29.

A preferred method of generating the new column 40 is to allow the user to place an operator such as a plus sign ("+")

44 between the salary and commission columns, as shown in FIG. 4. The system responds to the operator input in the location between two columns and generates the new column 42 of the salary column added to the commission column. The results are displayed to the user in the updated table of FIG. 5 having the new column 42. The user can immediately see the results of the operation for the sample data and know how the final output report will appear having the new column 42.

Further alterations which can be input by the user pertain to providing a range limitation on attributes, so as to identify those records having attributes in the specified range value. Referring to FIG. 6, a range limitation for the salary attribute 22 of being less than $20,000 ("20<") 50 has been input by the user (the table metaphor in FIGS. 3–8 has salary and commission values denoting thousands of dollars; so, for example, "20" denotes $20,000). Rows 27, 28 and 29 have been highlighted since these rows have salary attributes 51–53 within the specified range 50. In most database systems, a user wanting to query the database to find out for employees having a salary less than $20,000, the employees' names, IDs, salary amount, compensation commissions, total salary and commissions compensation, and department, have to write a query statement in the syntax of the database management system. Then, the output from the query has to be formatted for the report, also using the proper syntax of the query language. The user may run the query and view the report only to determine that there are no employees satisfying the specified condition. In this system, the user can identify what type of range values to specify based on the sample data attribute values. Therefore, this system makes it easier to compose reports with the relevant data which otherwise would have to be specified by using a query language.

In a preferred embodiment of the invention, in order to find all the employees whose salaries are less than $20,000, for example, the user first selects an individual salary by clicking on the cell containing that salary value using a mouse or other interactive device. Next, the user types an operator such as a "<" sign in the selected column. A select row 56 is added to the table metaphor to indicate the logical condition 50 the user has specified. The system using methods well-known to those skilled in the art determines which of the sample rows 25–29 have salary attribute values 22 meeting the specified condition 50. Each of the rows which fits into the sample data range as indicated in the select row 56 are highlighted (51–53 in FIG. 6).

Further conditions can be included as criteria for selecting rows that will be output in the final report, that is conditions for the query. Referring to FIG. 7, the logical OR operator can be used in a condition input by the user. The addition of an OR operation can result from the user viewing the results of a previous condition. For example, after viewing the updated table metaphor in FIG. 6, the user may wish to also include information on employees who have less than $40,000 in commissions, in addition to the employees that have less than $20,000 in salary.

The new condition can be added by the user by positioning the cursor in a cell of the commission column 20 of the table metaphor and signalling the system. The system then adds a new select row 60. The user then adds the condition of "<40" 62 in the commission attribute cell of the new select row 60.

The rows 26, 27, 28, and 29 that have respective attributes that fall within the range of the conditions specified in either of the select rows 56,60 are highlighted as shown in FIG. 6. The highlighted rows correspond to employees that either have salaries less than $20,000 or commission compensations less than $40,000. In this way, a user is able to form a query involving an OR operation without having to know the syntax or logic of a formal query language.

The user also formulates queries involving an AND operation (adding a further condition to be satisfied), using the the select rows 56, 60. The user can move the cursor 15 to a select line and type in the condition in the cell corresponding to the attribute to have the additional condition.

Referring to FIG. 8, the user inputs alterations to the table metaphor corresponding to identifying employees (and attributes regarding the employees) that have a salary of less than $20,000 and have total compensation (salary+commission) of less than $50,000 and also identifying employees having commission compensation less than $40,000 and total compensation less than $50,000.

The foregoing is accomplished by the user typing the value of 50 and the 'less than' operator ('<') into the salary+commission cells 68 of the select rows 56,60. The select rows 56,60 shown in FIG. 8 are logically equivalent to ((commission less than 40) and (salary plus commission less than 50)) or ((salary less than 20) and (salary plus commission) less than 50).

Using this system, the user can decide based on the highlighted sample data in FIG. 7 that the desired report should also contain output on individuals whose salary is less than $20,000 or whose commission is less than $40,000, provided that the total compensation is less than $50,000. If a query language statement had to be generated, the user would have to figure out how to generate the appropriate query using ANDs and ORs.

As illustrated in the foregoing examples, complex queries can be interactively formulated using the table metaphor to incrementally add more query conditions. More complex queries can be built using this method as would be known to those skilled in the art.

There are many improvements of using the invention. The query requires fewer terms than a query in SQL. The context of the interface supplies much of the information that users have to type in using other query methods. For example, by clicking directly on a column, the user is specifying that the next condition entered will apply to that column. It is also easier for users to understand what the query will do. For example, having the sample data highlighted which matches the query allows users to check and refine the query before sending it off to the database. The users thus have a more accurate understanding of the query before it is issued. The user also interacts naturally with the database using the metaphor tables. There is also no need to remember commands or syntax for moving or combining columns. The sample data also helps the user to refine the data more accurately and to include or exclude conditions from the query that might not otherwise be as easily incorporated.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various other changes in the form and details may be made therein without departing from the spirit and scope of the invention. Accordingly, the method and system herein disclosed are to be considered merely as illustrative and the invention is to be limited only as specified in the claims.

We claim:

1. A computer program on a computer usable medium having computer readable program code means embodied in said medium for generating a report by enabling a user to

interact with a computer system connected to a storage device having a database of data, comprising:

computer readable program code means for causing a displaying, on a display screen of the computer system, of a table metaphor having rows and columns of attribute value cells, the attribute value cells containing attribute values reflective of a subset of attribute values of the database data;

computer readable program code means for causing a registering of direct alterations to the table metaphor;

computer readable program code means for causing a displaying, on the display screen, of a revised table metaphor graphically representing a revised report format reflecting the registered direct alterations;

computer readable program code means for causing a query statement, corresponding to the revised table metaphor, to be determined; and

computer readable program code means for causing a running of the query statement on the database to produce query output in the revised report format.

2. A computer program on a computer usable medium having computer readable program code means embodied in said medium for formulating a report using data contained in a database stored in a storage device, comprising:

computer readable program code means for causing a providing of a subset of the database data in a displayed metaphor table on a display device of a computer system connected to said storage device;

computer readable program code means for causing a registering of at least one direct alteration to the metaphor table to graphically represent a report format;

computer readable program code means for causing a query, corresponding to the report format, to be determined; and

computer readable program code means for causing a running of the query on the database data to produce the report in the report format.

* * * * *

US005870746

United States Patent [19]

Knutson et al.

[11] **Patent Number: 5,870,746**

[45] **Date of Patent: Feb. 9, 1999**

102(b)

[54] **SYSTEM AND METHOD FOR SEGMENTING A DATABASE BASED UPON DATA ATTRIBUTES**

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[73] Assignee: **NCR Corporation**, Dayton, Ohio

[21] Appl. No.: **742,007**

[22] Filed: **Oct. 31, 1996**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 542,266, Oct. 12, 1995, abandoned.

[51] **Int. Cl.**[6] **G06F 17/30**

[52] **U.S. Cl.** **707/101**; 707/10

[58] **Field of Search** 707/1–5, 10; 1/100–102

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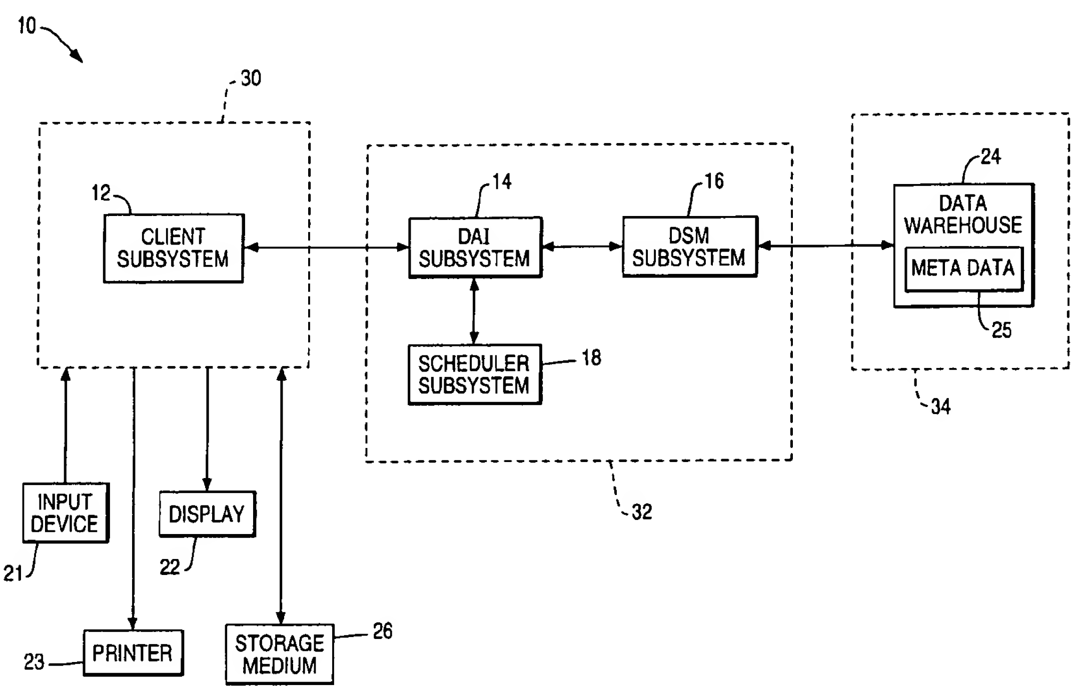
Primary Examiner—Maria N. Von Buhr

Attorney, Agent, or Firm—Needle & Rosenberg; Peter H. Priest

[57] **ABSTRACT**

A system and method for allowing a user to segment and partition a database based upon attributes associated with the data in the database. Also, a system and method for generating a report for a user which allows the user to make decisions, without requiring the user to understand or interpret data itself. A database computer includes a database containing the data. The data includes a collection of information about an enterprise of the user. A server computer is coupled to the database computer and executes a database management program. A client computer is coupled to the server and executes an application program. The application program allows a user to define predetermined data types, to define relationships between the data types, to define parameters for the report, to define a method of analysis for the report, and to create the report. The report summarizes the data in terms of the data types, the data relationships, and the method of analysis.

10 Claims, 33 Drawing Sheets



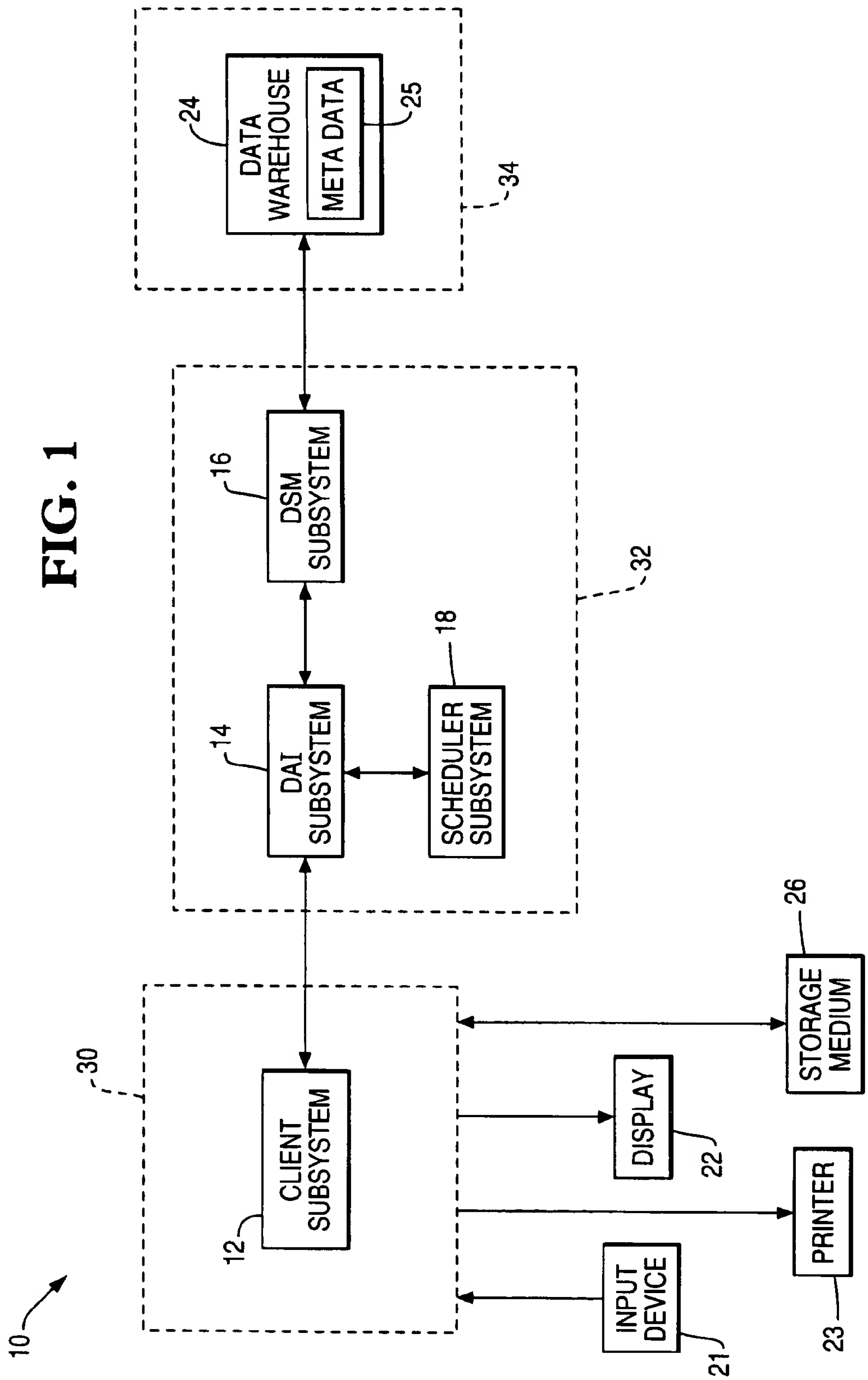
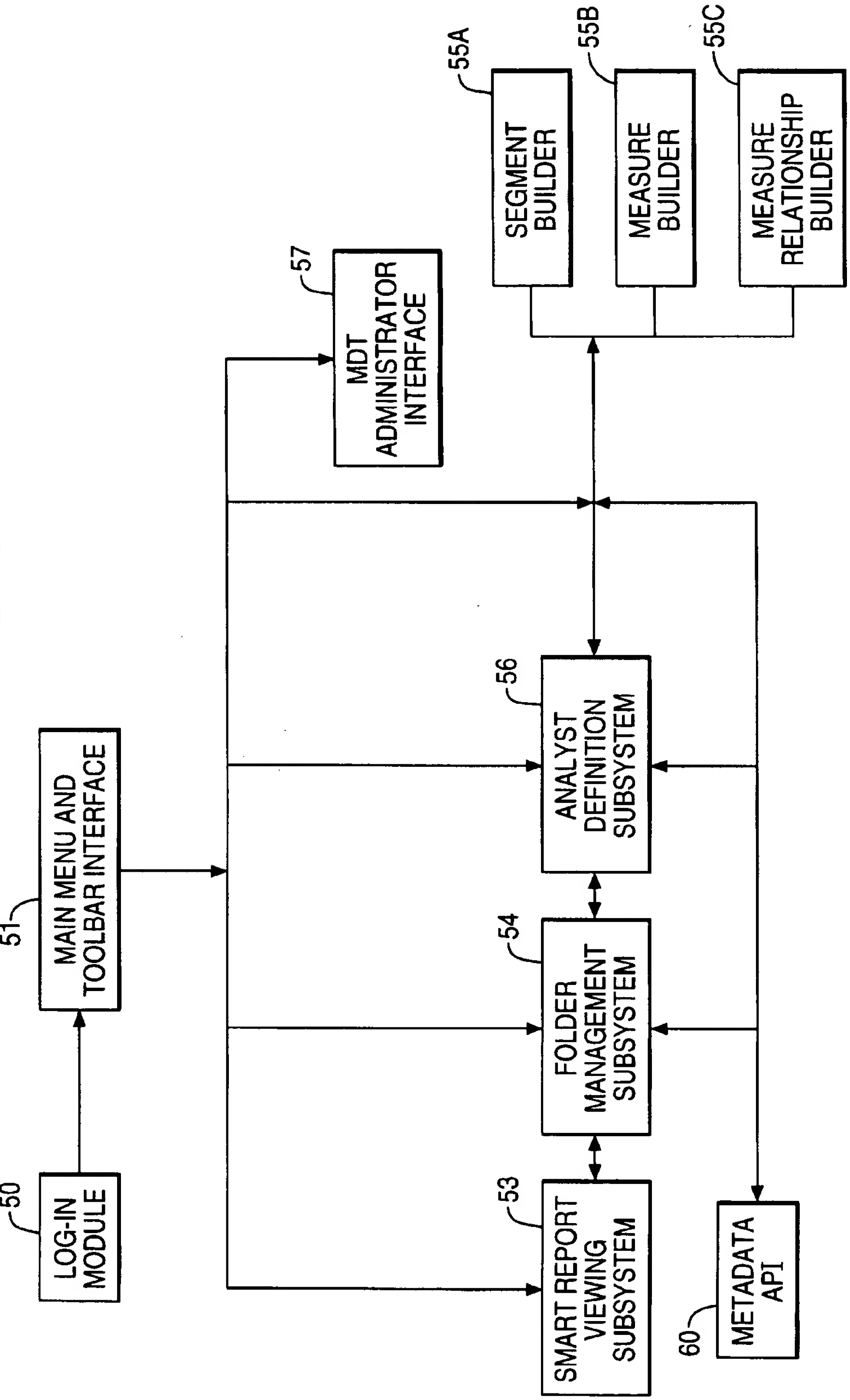

DATA WAREHOUSE
META DATA
24
25
34
DSM SUBSYSTEM
16
32
DAI SUBSYSTEM
14
SCHEDULER SUBSYSTEM
18
CLIENT SUBSYSTEM
12
30
10
STORAGE MEDIUM
26
DISPLAY
22
PRINTER
23
INPUT DEVICE
21

FIG. 1



LOG-IN MODULE
50
MAIN MENU AND TOOLBAR INTERFACE
51
SMART REPORT VIEWING SUBSYSTEM
53
FOLDER MANAGEMENT SUBSYSTEM
54
ANALYST DEFINITION SUBSYSTEM
56
MDT ADMINISTRATOR INTERFACE
57
SEGMENT BUILDER
55A
MEASURE BUILDER
55B
MEASURE RELATIONSHIP BUILDER
55C
METADATA API
60

FIG. 2

FIG. 3

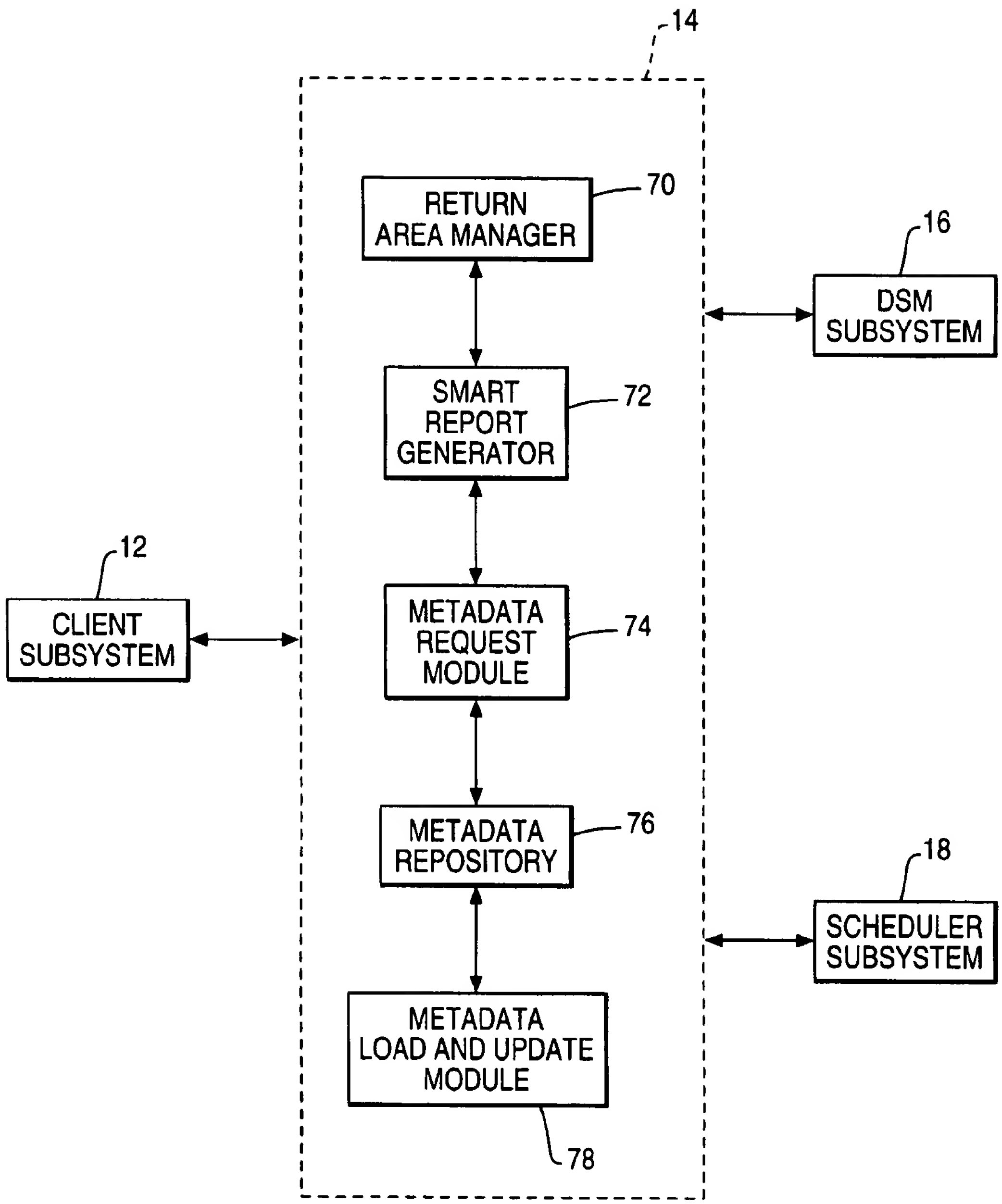

14
RETURN AREA MANAGER
70
SMART REPORT GENERATOR
72
METADATA REQUEST MODULE
74
METADATA REPOSITORY
76
METADATA LOAD AND UPDATE MODULE
78
12
CLIENT SUBSYSTEM
16
DSM SUBSYSTEM
18
SCHEDULER SUBSYSTEM

FIG. 4

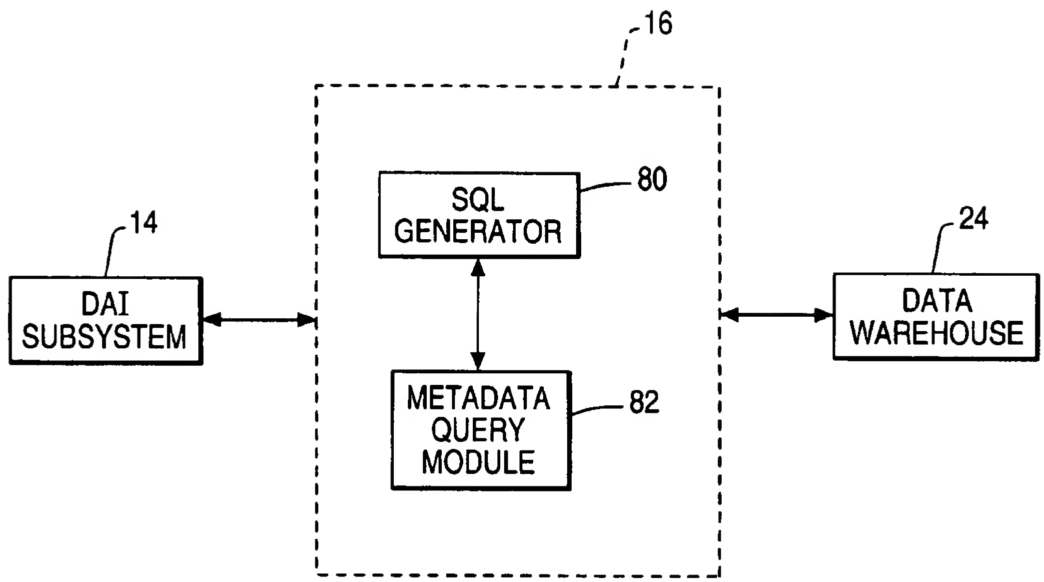

16
SQL GENERATOR
80
14
24
DAI SUBSYSTEM
DATA WAREHOUSE
METADATA QUERY MODULE
82

FIG. 5

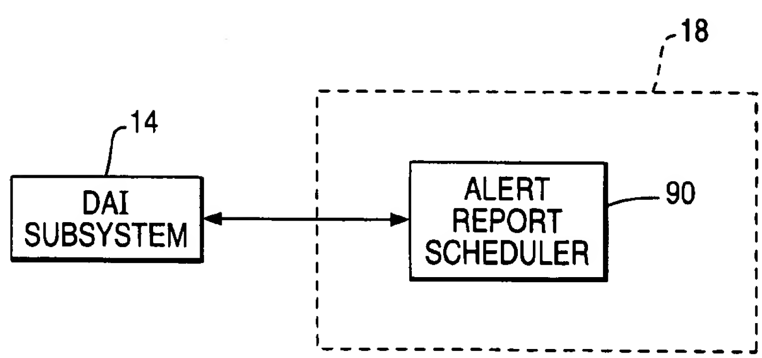
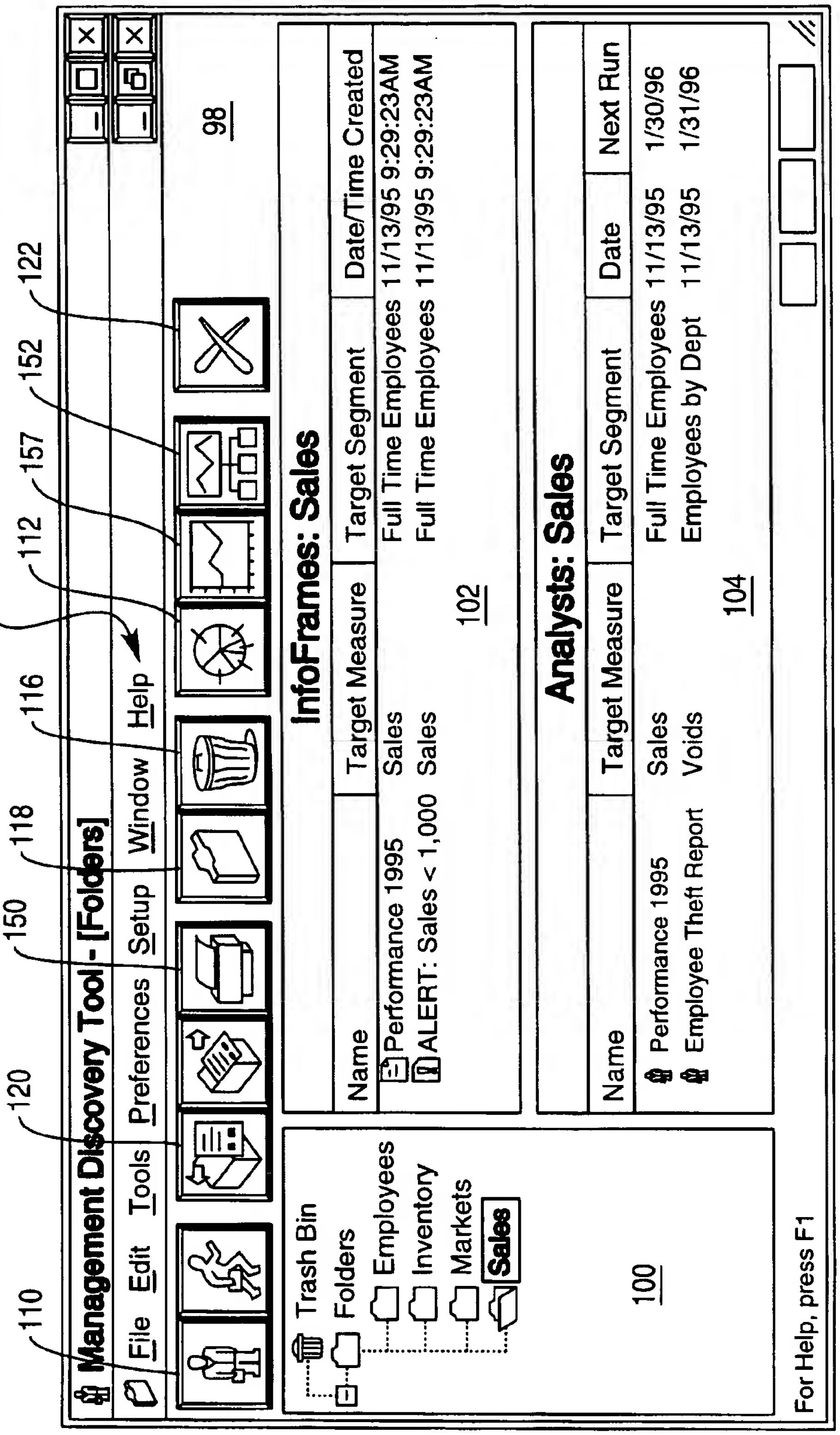

18
14
DAI SUBSYSTEM
ALERT REPORT SCHEDULER
90

FIG. 6


Management Discovery Tool - [Folders]
File Edit Tools Preferences Setup Window Help
98
106
110
120
150
118
116
112
157
152
122
Trash Bin
Folders
Employees
Inventory
Markets
Sales
100
InfoFrames: Sales
Name
Target Measure
Target Segment
Date/Time Created
Performance 1995
Sales
Full Time Employees
11/13/95 9:29:23AM
ALERT: Sales < 1,000
Sales
Full Time Employees
11/13/95 9:29:23AM
102
Analysis: Sales
Name
Target Measure
Target Segment
Date
Next Run
Performance 1995
Sales
Full Time Employees
11/13/95
1/30/96
Employee Theft Report
Voids
Employees by Dept
11/13/95
1/31/96
104
For Help, press F1

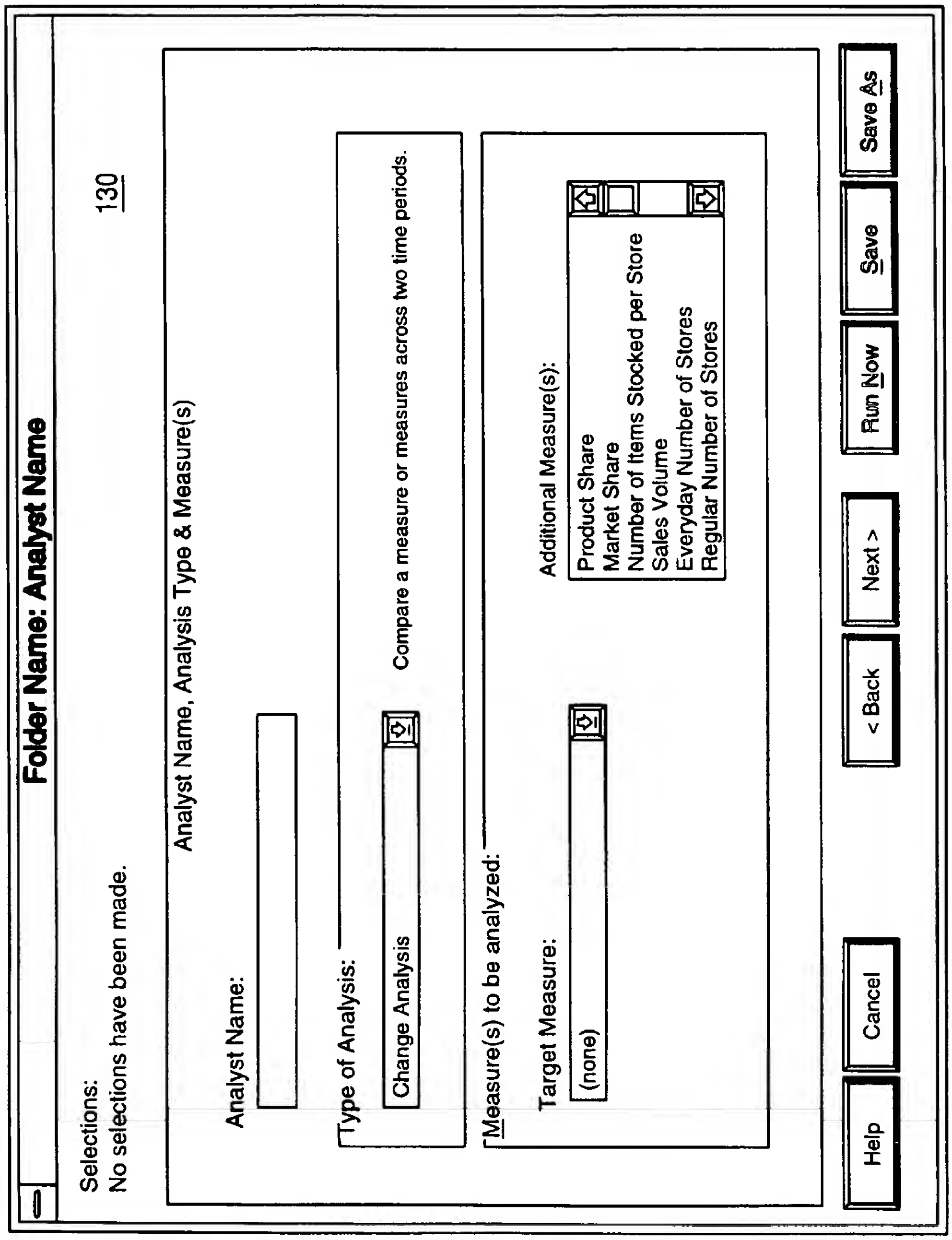
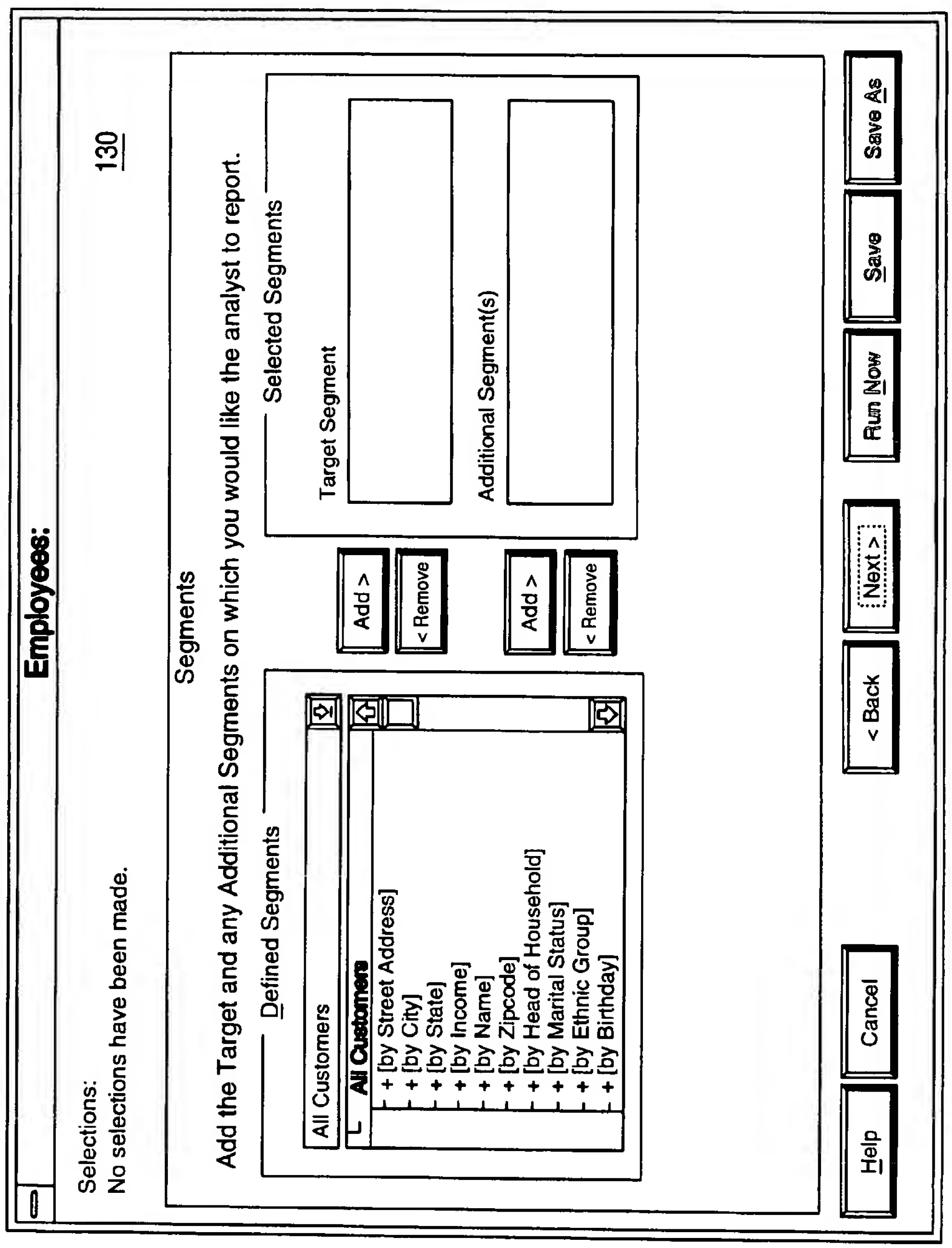

Folder Name: Analyst Name
Selections:
No selections have been made.
130
Analyst Name, Analysis Type & Measure(s)
Analyst Name:
Type of Analysis:
Change Analysis
Compare a measure or measures across two time periods.
Measure(s) to be analyzed:
Target Measure:
(none)
Additional Measure(s):
Product Share
Market Share
Number of Items Stocked per Store
Sales Volume
Everyday Number of Stores
Regular Number of Stores
Help
Cancel
< Back
Next >
Run Now
Save
Save As

FIG. 7A



Employees:
130
Selections:
No selections have been made.
Segments
Add the Target and any Additional Segments on which you would like the analyst to report.
Defined Segments
All Customers
All Customers
+ [by Street Address]
+ [by City]
+ [by State]
+ [by Income]
+ [by Name]
+ [by Zipcode]
+ [by Head of Household]
+ [by Marital Status]
+ [by Ethnic Group]
+ [by Birthday]
Add >
< Remove
Add >
< Remove
Selected Segments
Target Segment
Additional Segment(s)
Help
Cancel
< Back
Next >
Run Now
Save
Save As

FIG. 7B

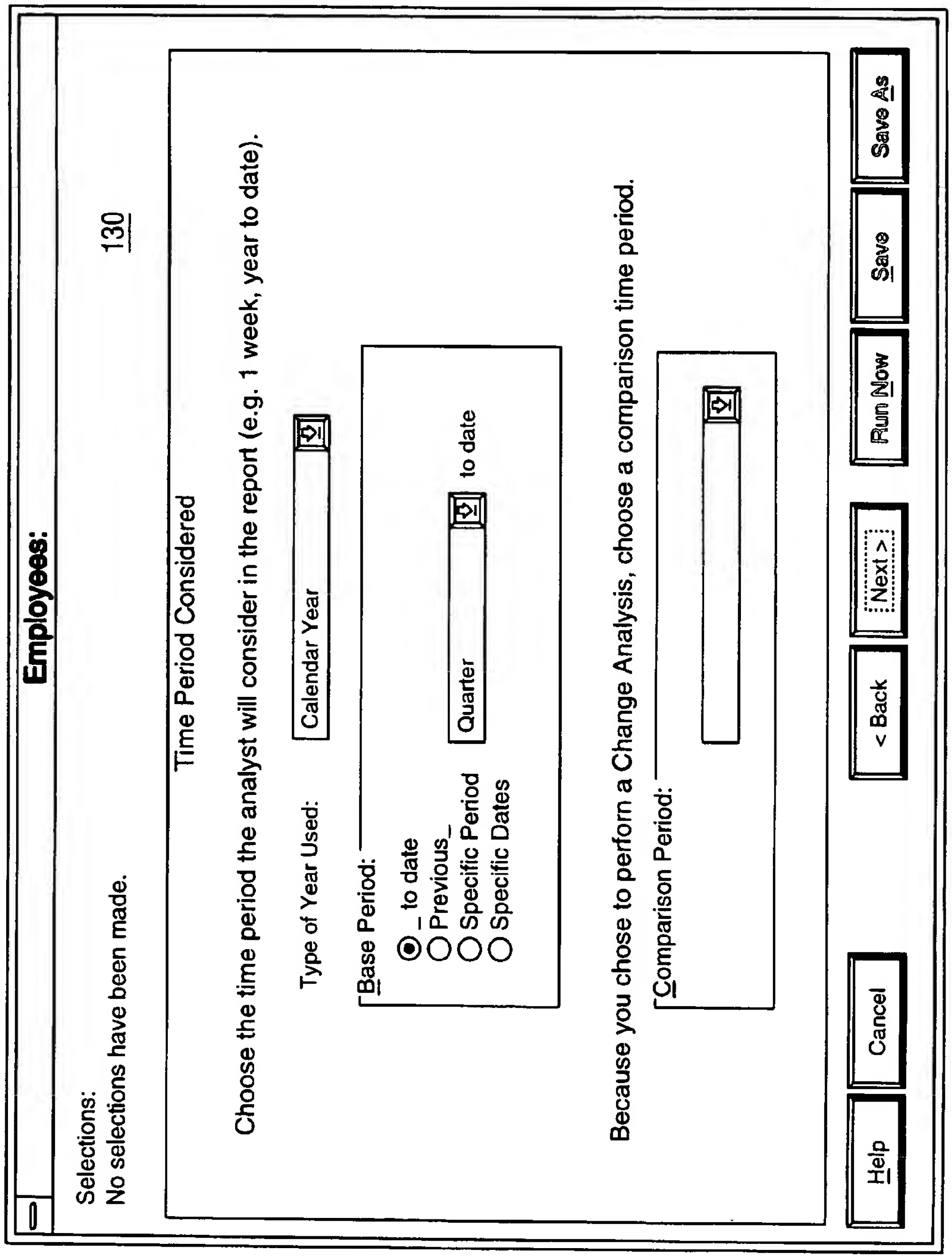

Employees:
Selections:
No selections have been made.
130
Time Period Considered
Choose the time period the analyst will consider in the report (e.g. 1 week, year to date).
Type of Year Used:
Calendar Year
Base Period:
_ to date
Previous_
Specific Period
Specific Dates
Quarter
to date
Because you chose to perform a Change Analysis, choose a comparison time period.
Comparison Period:
Help
Cancel
< Back
Next >
Run Now
Save
Save As

FIG. 7C

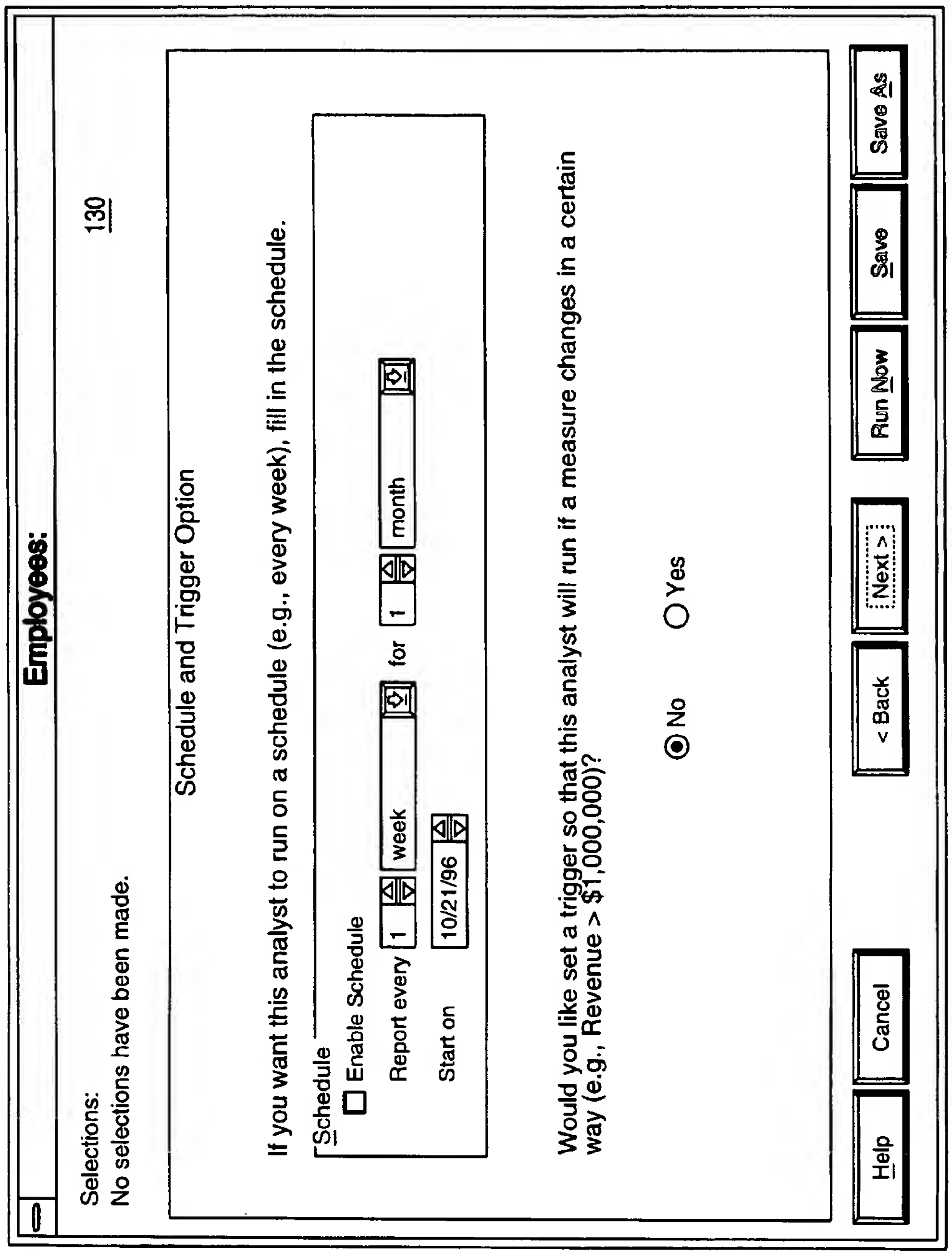

Employees:
130
Selections:
No selections have been made.
Schedule and Trigger Option
If you want this analyst to run on a schedule (e.g., every week), fill in the schedule.
Schedule
Enable Schedule
Report every
1
week
for
1
month
Start on
10/21/96
Would you like set a trigger so that this analyst will run if a measure changes in a certain way (e.g., Revenue > $1,000,000)?
No
Yes
Help
Cancel
< Back
Next >
Run Now
Save
Save As

FIG. 7D

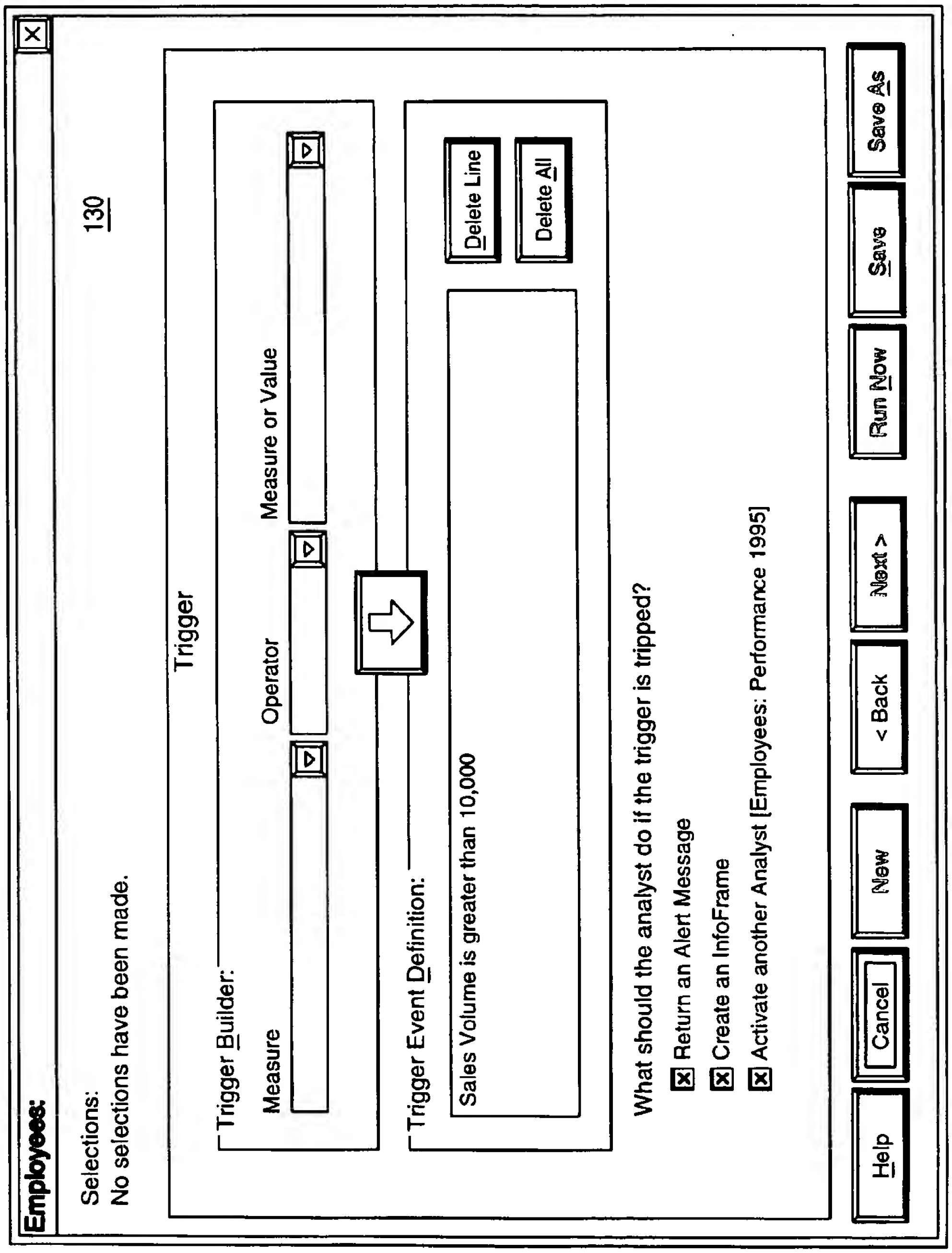

Employees:
Selections:
No selections have been made.
130
Trigger
Trigger Builder:
Measure
Operator
Measure or Value
Trigger Event Definition:
Sales Volume is greater than 10,000
Delete Line
Delete All
What should the analyst do if the trigger is tripped?
Return an Alert Message
Create an InfoFrame
Activate another Analyst [Employees: Performance 1995]
Help
Cancel
New
< Back
Next >
Run Now
Save
Save As

FIG. 7E

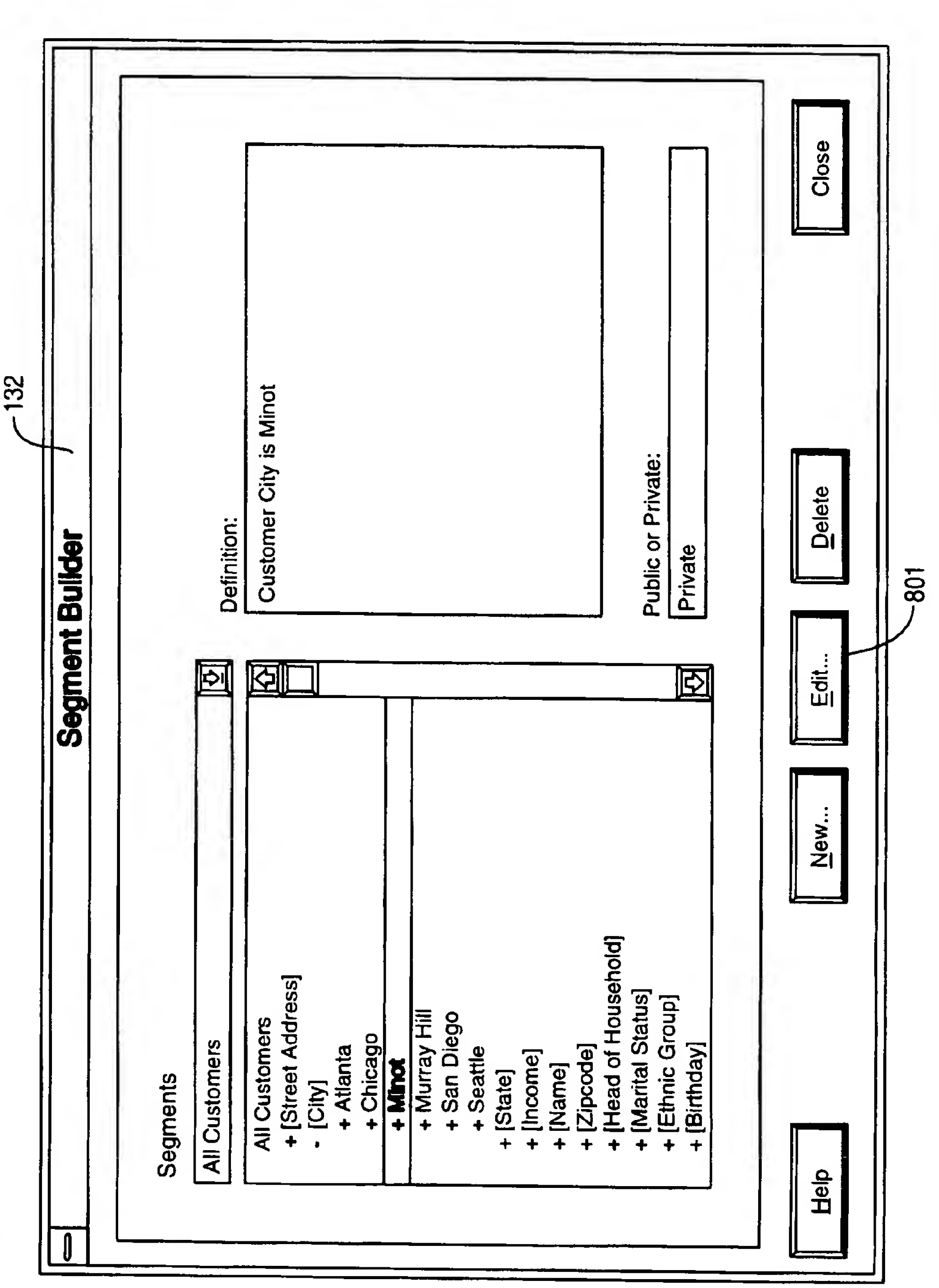

132
Segment Builder
Segments
All Customers
All Customers
+ [Street Address]
- [City]
+ Atlanta
+ Chicago
+ Minot
+ Murray Hill
+ San Diego
+ Seattle
+ [State]
+ [Income]
+ [Name]
+ [Zipcode]
+ [Head of Household]
+ [Marital Status]
+ [Ethnic Group]
+ [Birthday]
Definition:
Customer City is Minot
Public or Private:
Private
Help
New...
Edit...
Delete
Close
801

FIG. 8A

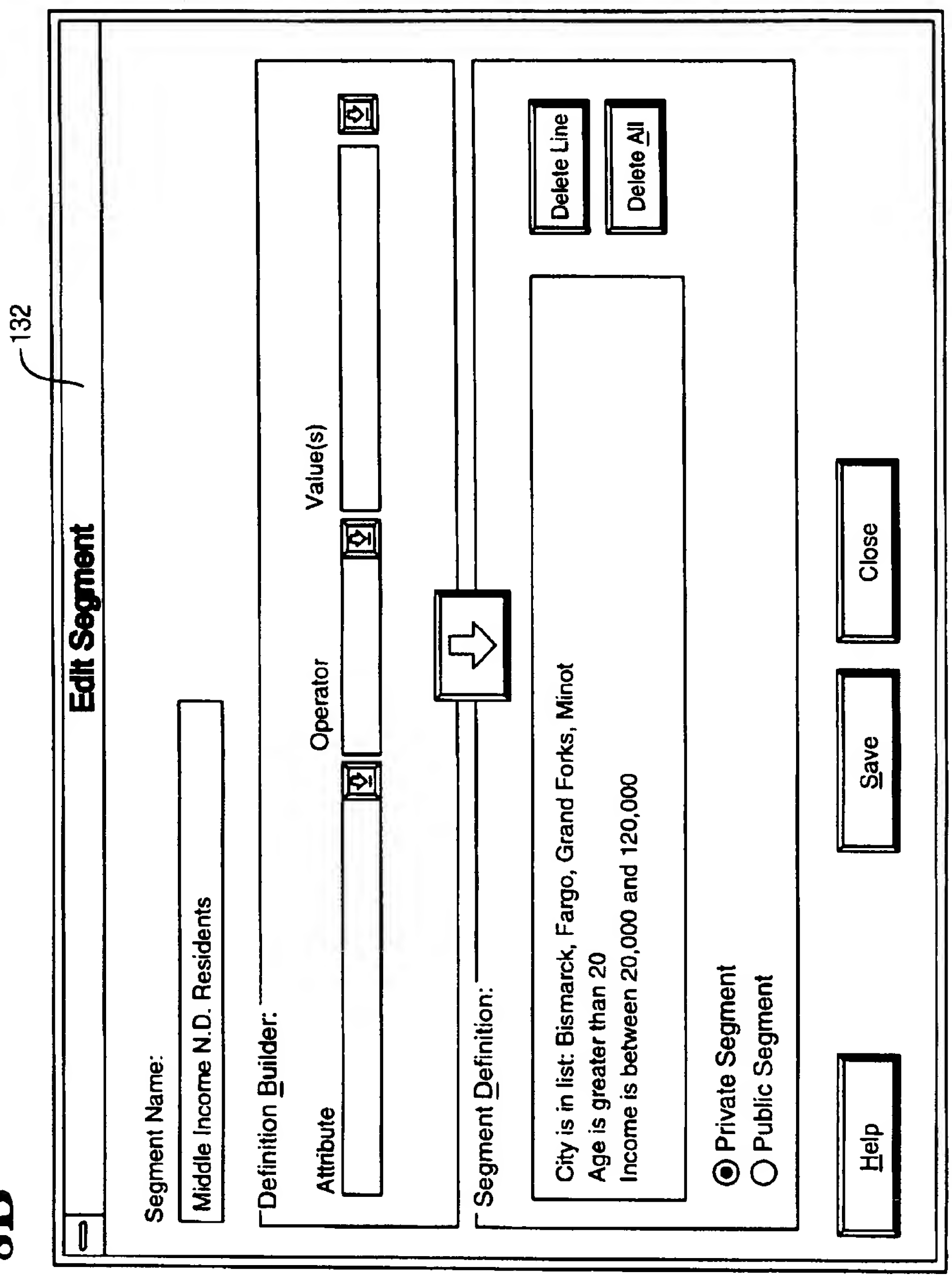
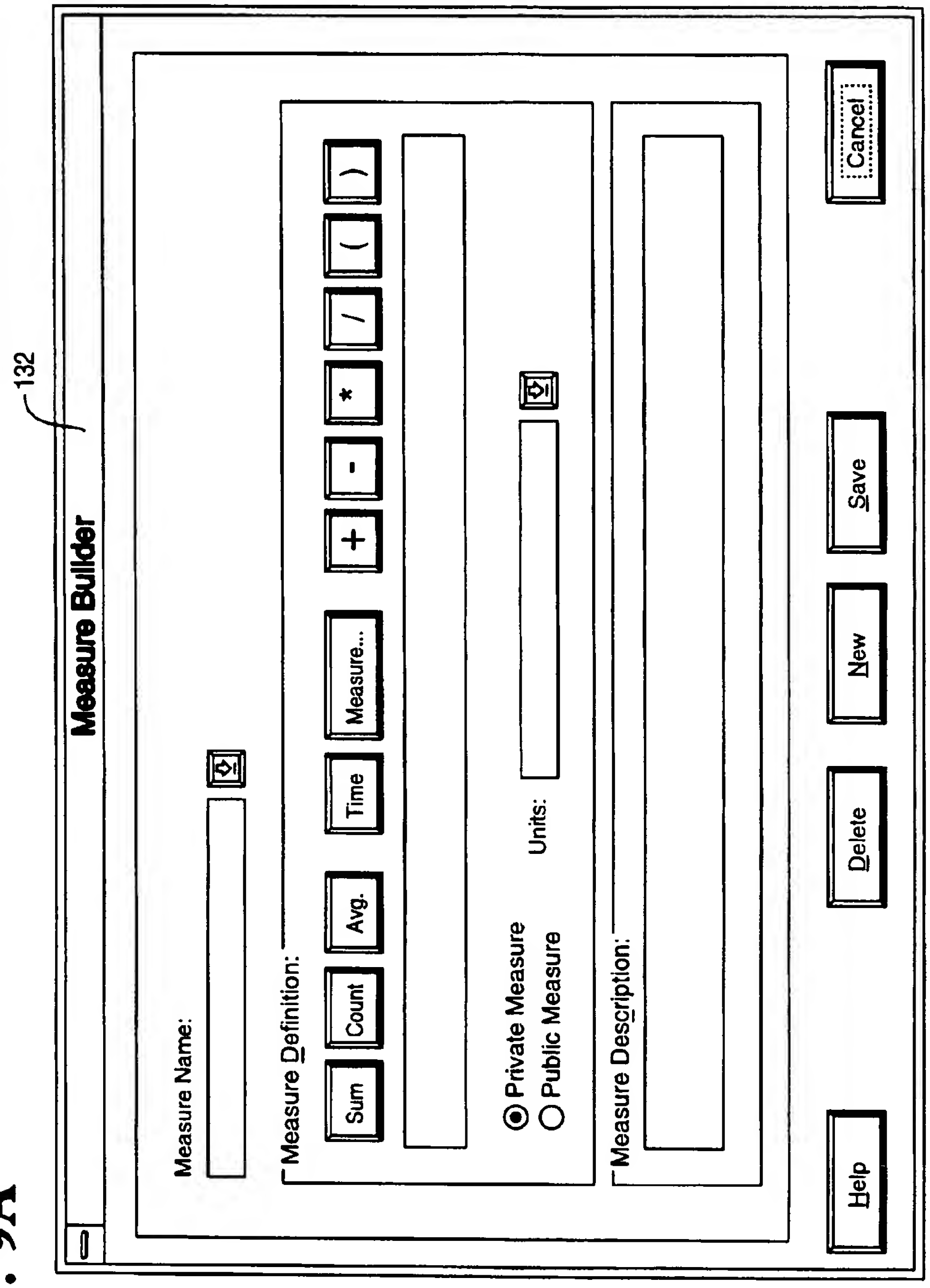

132
Edit Segment
Segment Name:
Middle Income N.D. Residents
Definition Builder:
Attribute
Operator
Value(s)
Segment Definition:
City is in list: Bismarck, Fargo, Grand Forks, Minot
Age is greater than 20
Income is between 20,000 and 120,000
Private Segment
Public Segment
Delete Line
Delete All
Help
Save
Close

FIG. 8B

FIG. 9A


132
Measure Builder
Measure Name:
Measure Definition:
Sum
Count
Avg.
Time
Measure...
+
-
*
/
(
)
Private Measure
Public Measure
Units:
Measure Description:
Help
Delete
New
Save
Cancel

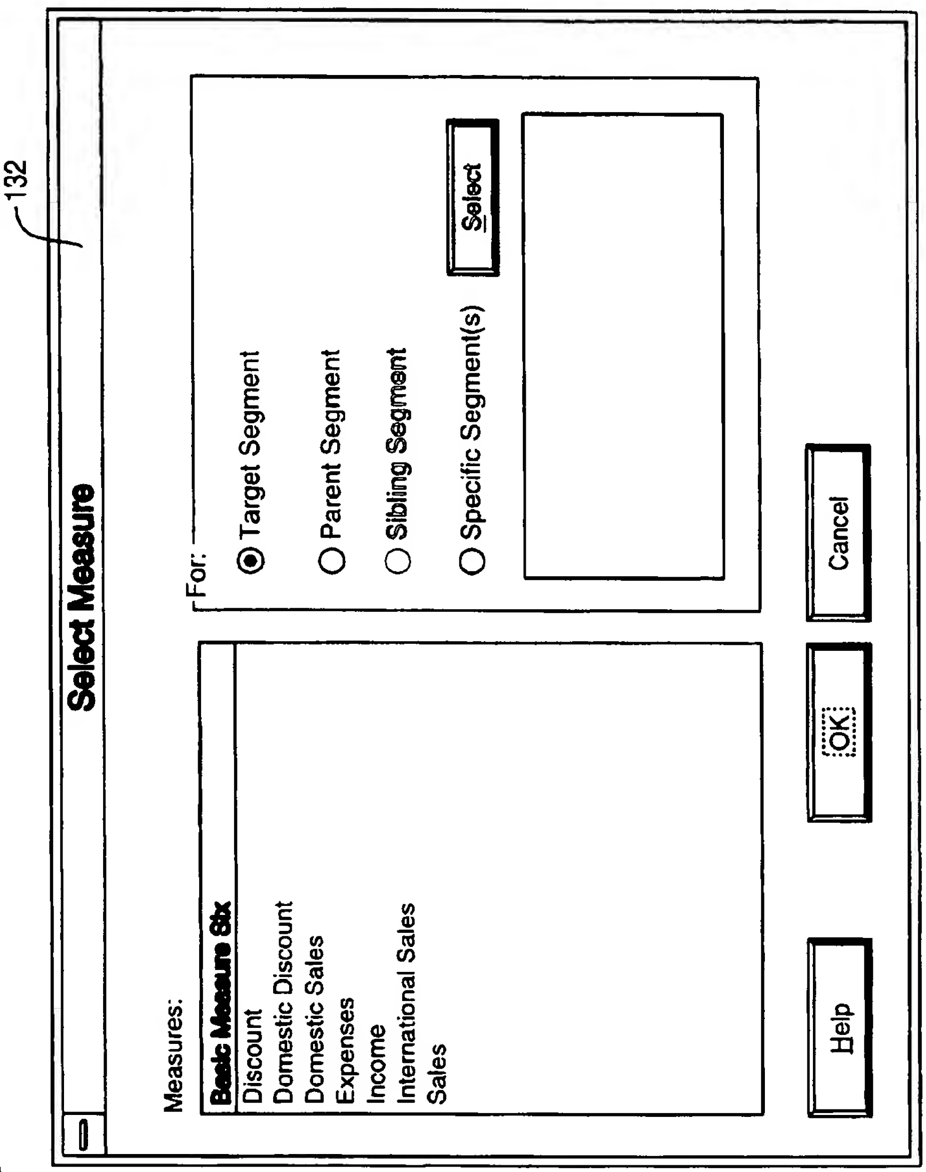

132
Select Measure
Measures:
Basic Measure Stx
Discount
Domestic Discount
Domestic Sales
Expenses
Income
International Sales
Sales
For:
Target Segment
Parent Segment
Sibling Segment
Specific Segment(s)
Select
Help
OK
Cancel

FIG. 9B

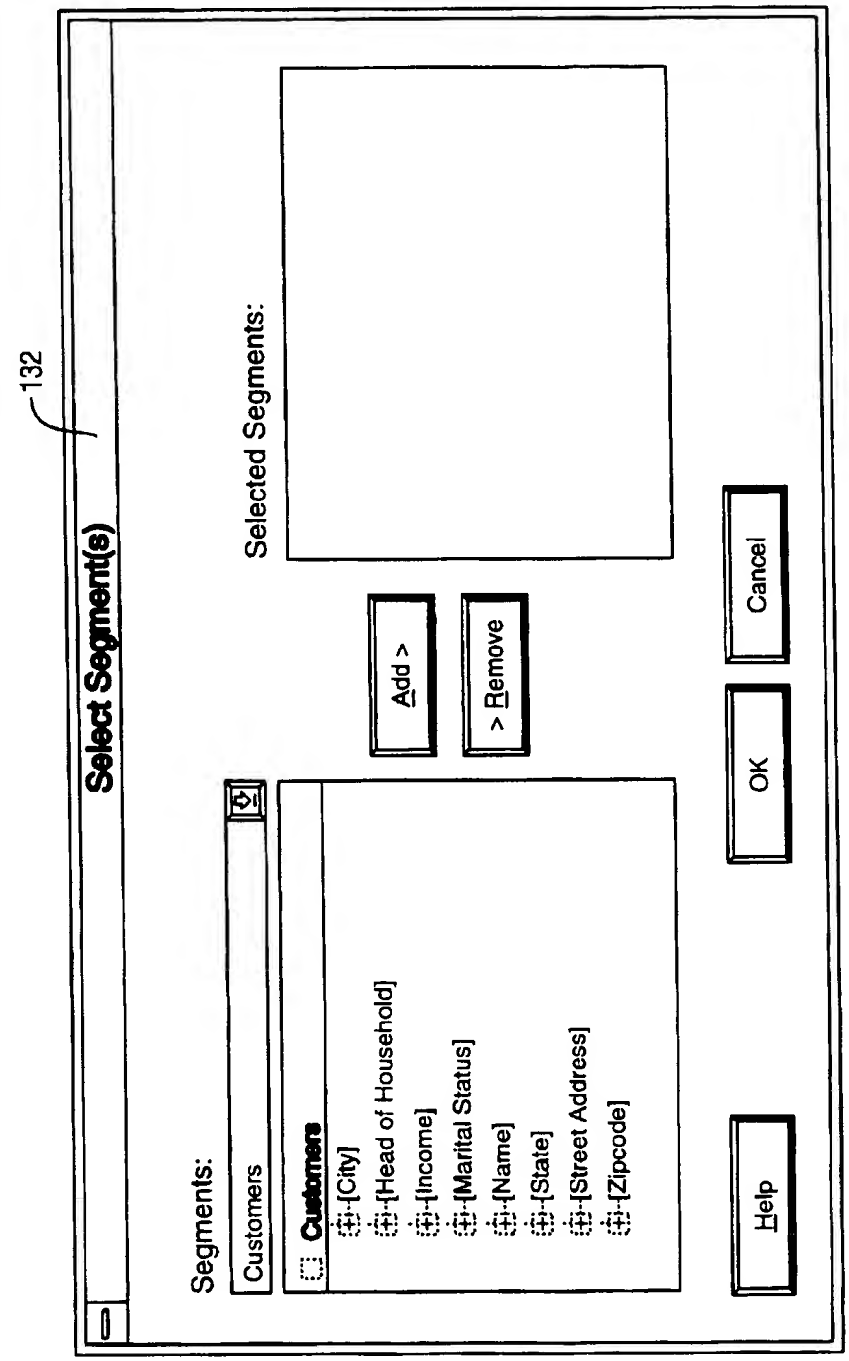
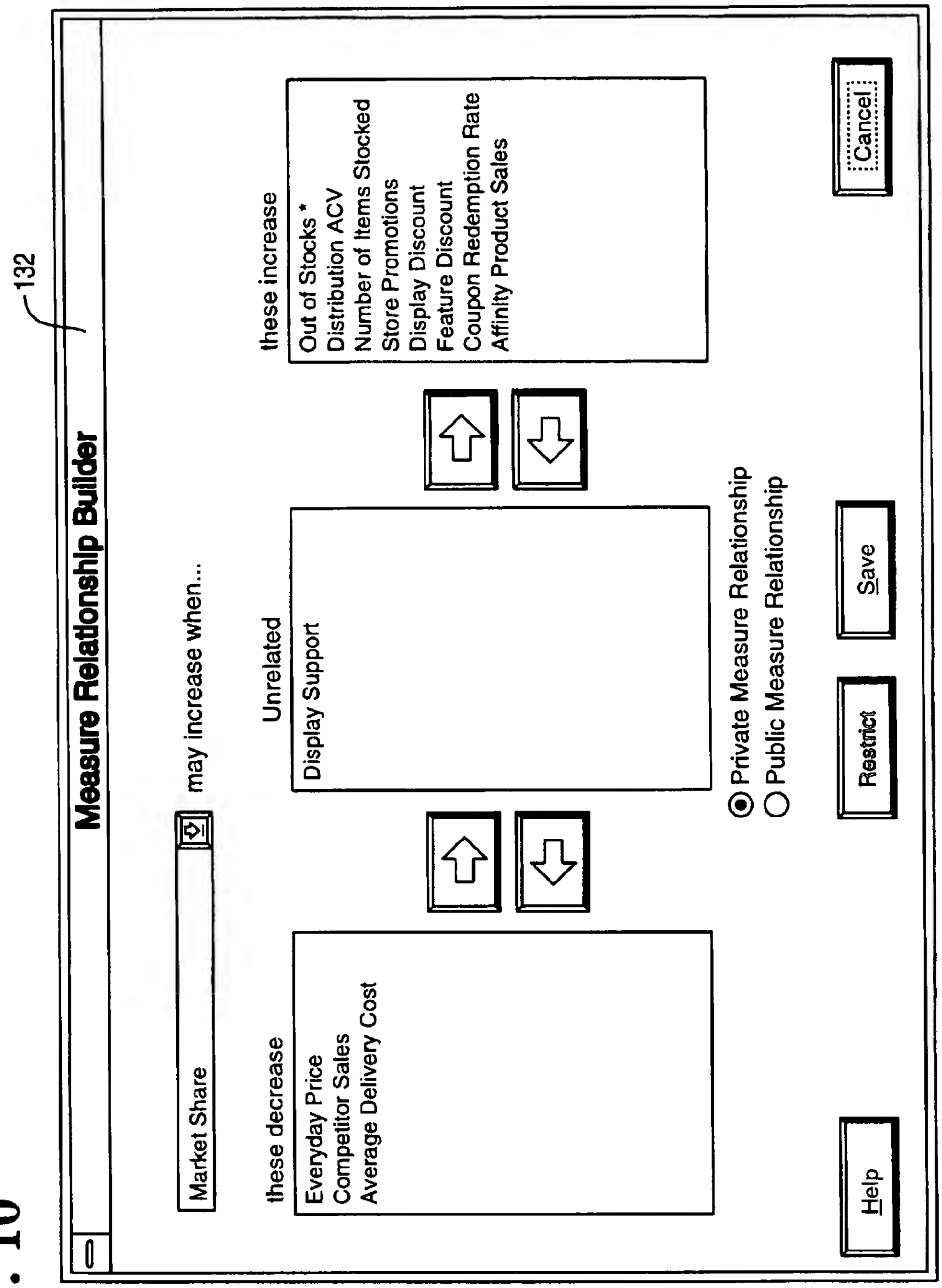

Select Segment(s)
132
Segments:
Customers
Customers
[City]
[Head of Household]
[Income]
[Marital Status]
[Name]
[State]
[Street Address]
[Zipcode]
Add >
> Remove
Selected Segments:
OK
Cancel
Help

FIG. 9C

FIG. 10


132
Measure Relationship Builder
Market Share
may increase when...
these decrease
Everyday Price
Competitor Sales
Average Delivery Cost
Unrelated
Display Support
these increase
Out of Stocks *
Distribution ACV
Number of Items Stocked
Store Promotions
Display Discount
Feature Discount
Coupon Redemption Rate
Affinity Product Sales
Private Measure Relationship
Public Measure Relationship
Help
Restrict
Save
Cancel

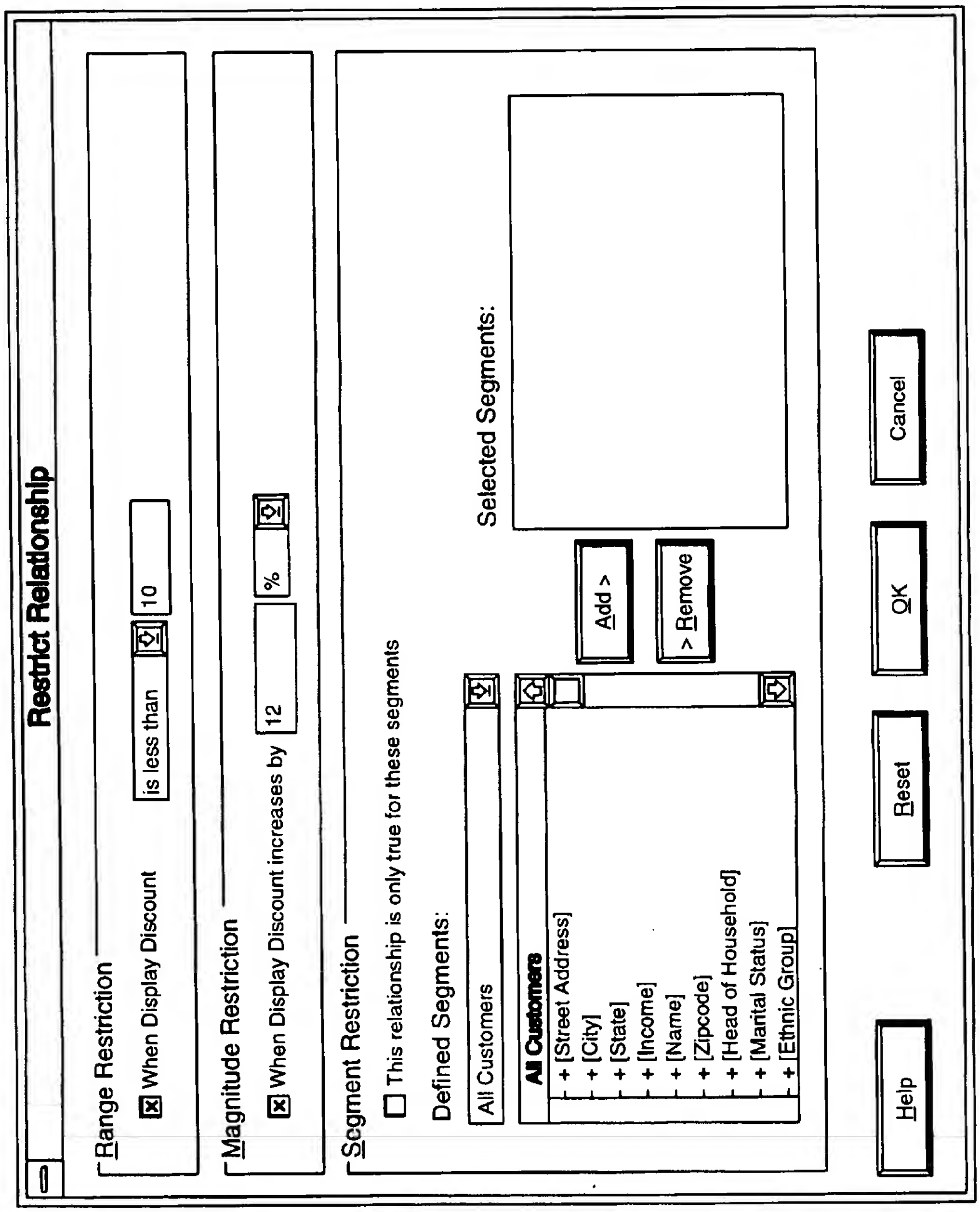

Restrict Relationship
Range Restriction
When Display Discount
is less than
10
Magnitude Restriction
When Display Discount increases by
12
%
Segment Restriction
This relationship is only true for these segments
Defined Segments:
All Customers
All Customers
+ [Street Address]
+ [City]
+ [State]
+ [Income]
+ [Name]
+ [Zipcode]
+ [Head of Household]
+ [Marital Status]
+ [Ethnic Group]
Add >
> Remove
Selected Segments:
Help
Reset
OK
Cancel

FIG. 11

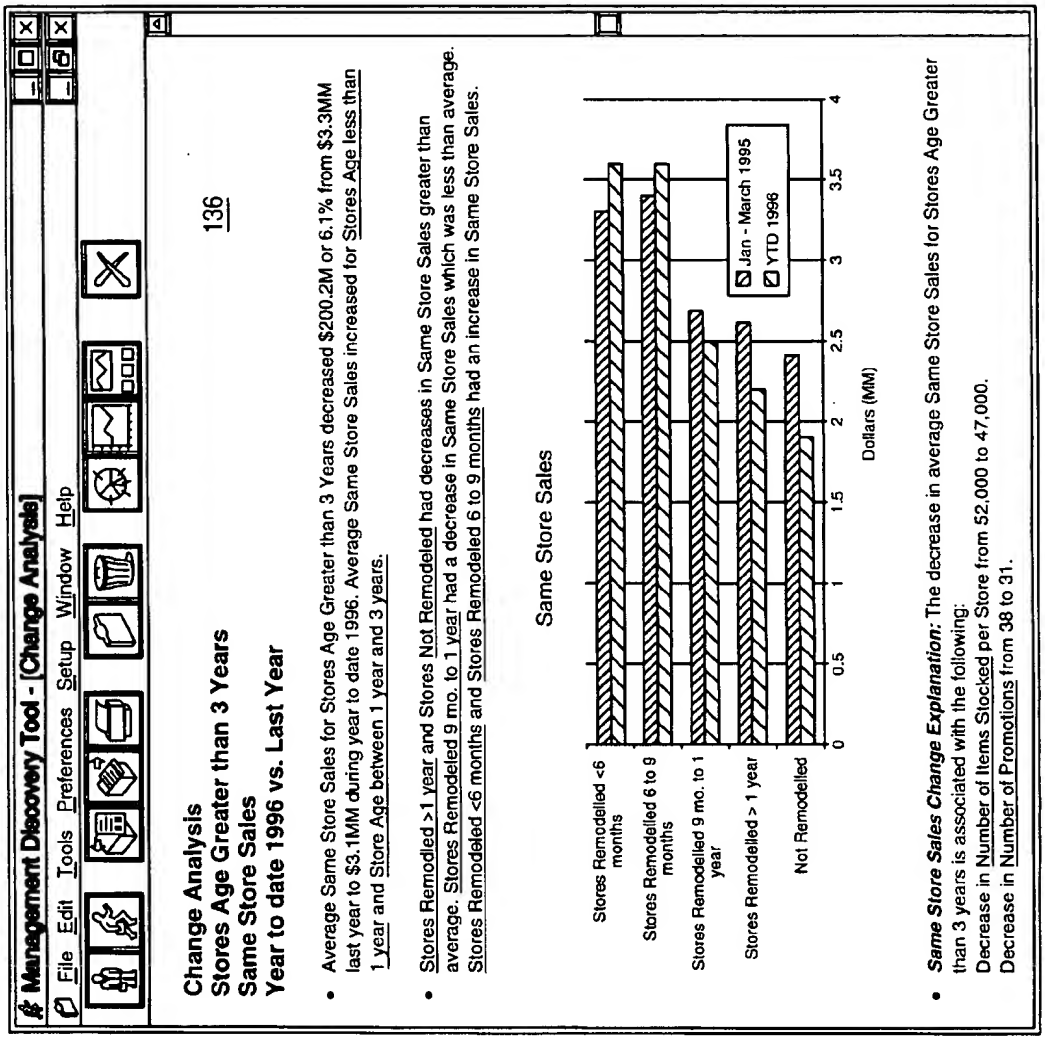
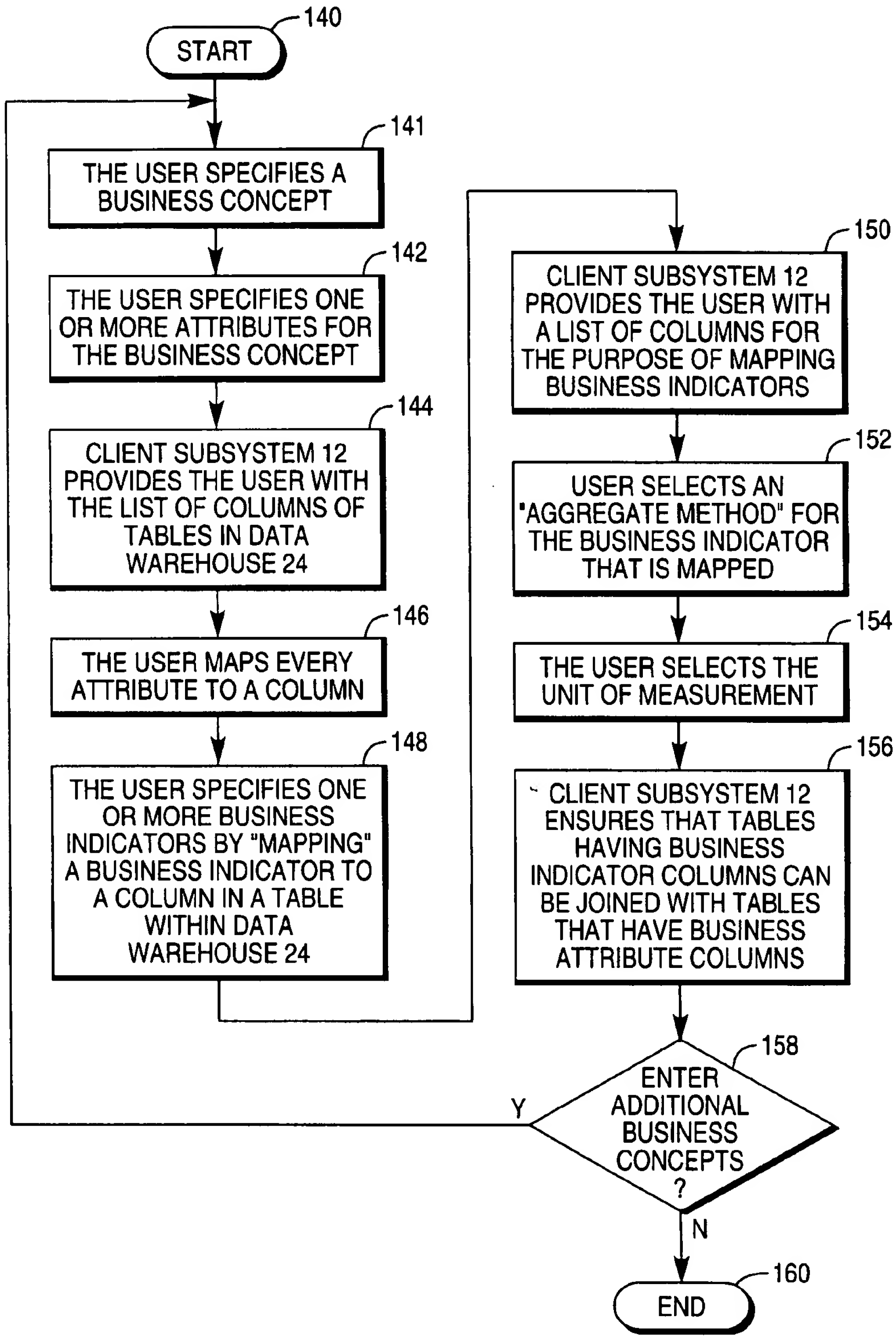

Management Discovery Tool - [Change Analysis]
File Edit Tools Preferences Setup Window Help
136
Change Analysis
Stores Age Greater than 3 Years
Same Store Sales
Year to date 1996 vs. Last Year
• Average Same Store Sales for Stores Age Greater than 3 Years decreased $200.2M or 6.1% from $3.3MM last year to $3.1MM during year to date 1996. Average Same Store Sales increased for Stores Age less than 1 year and Store Age between 1 year and 3 years.
• Stores Remodeled >1 year and Stores Not Remodeled had decreases in Same Store Sales greater than average. Stores Remodeled 9 mo. to 1 year had a decrease in Same Store Sales which was less than average. Stores Remodeled <6 months and Stores Remodeled 6 to 9 months had an increase in Same Store Sales.
Same Store Sales
Stores Remodelled <6 months
Stores Remodelled 6 to 9 months
Stores Remodelled 9 mo. to 1 year
Stores Remodelled > 1 year
Not Remodelled
Jan - March 1995
YTD 1996
0
0.5
1
1.5
2
2.5
3
3.5
4
Dollars (MM)
• Same Store Sales Change Explanation: The decrease in average Same Store Sales for Stores Age Greater than 3 years is associated with the following:
Decrease in Number of Items Stocked per Store from 52,000 to 47,000.
Decrease in Number of Promotions from 38 to 31.

FIG. 12

FIG. 13


140
START
141
THE USER SPECIFIES A BUSINESS CONCEPT
142
THE USER SPECIFIES ONE OR MORE ATTRIBUTES FOR THE BUSINESS CONCEPT
144
CLIENT SUBSYSTEM 12 PROVIDES THE USER WITH THE LIST OF COLUMNS OF TABLES IN DATA WAREHOUSE 24
146
THE USER MAPS EVERY ATTRIBUTE TO A COLUMN
148
THE USER SPECIFIES ONE OR MORE BUSINESS INDICATORS BY "MAPPING" A BUSINESS INDICATOR TO A COLUMN IN A TABLE WITHIN DATA WAREHOUSE 24
150
CLIENT SUBSYSTEM 12 PROVIDES THE USER WITH A LIST OF COLUMNS FOR THE PURPOSE OF MAPPING BUSINESS INDICATORS
152
USER SELECTS AN "AGGREGATE METHOD" FOR THE BUSINESS INDICATOR THAT IS MAPPED
154
THE USER SELECTS THE UNIT OF MEASUREMENT
156
CLIENT SUBSYSTEM 12 ENSURES THAT TABLES HAVING BUSINESS INDICATOR COLUMNS CAN BE JOINED WITH TABLES THAT HAVE BUSINESS ATTRIBUTE COLUMNS
158
ENTER ADDITIONAL BUSINESS CONCEPTS ?
Y
N
160
END

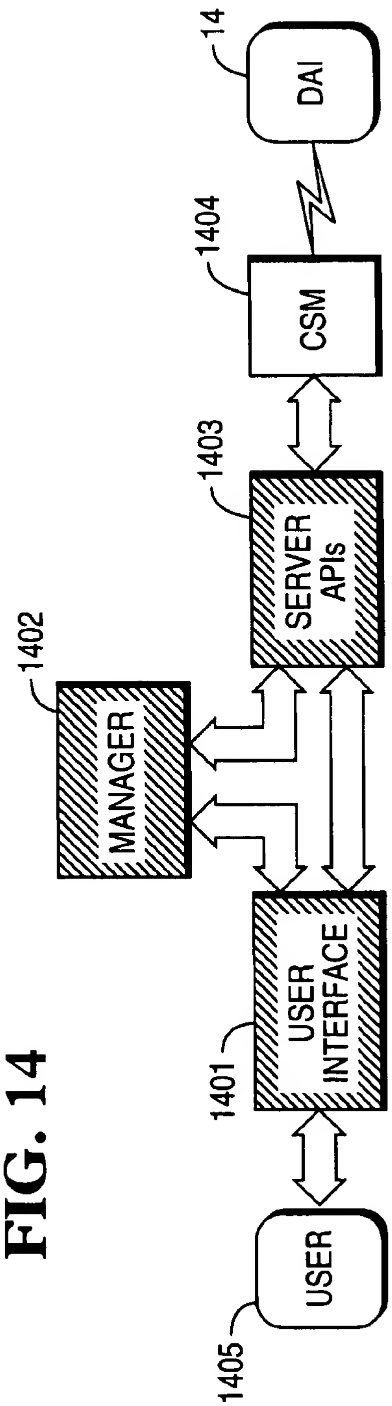

14
DAI
1404
CSM
1403
SERVER APIs
1402
MANAGER
1401
USER INTERFACE
1405
USER

FIG. 14

FIG. 15

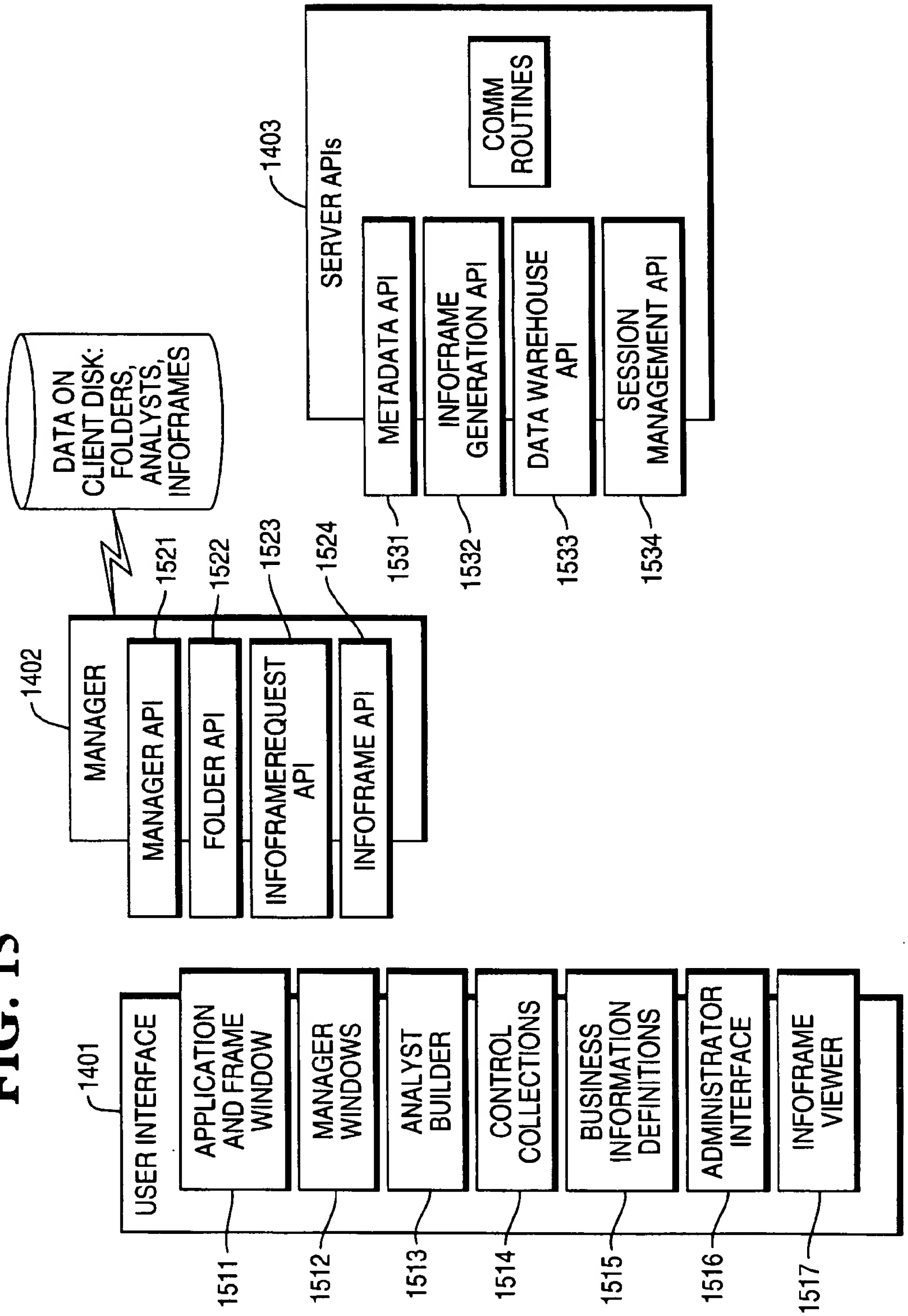

1401
USER INTERFACE
APPLICATION AND FRAME WINDOW
1511
MANAGER WINDOWS
1512
ANALYST BUILDER
1513
CONTROL COLLECTIONS
1514
BUSINESS INFORMATION DEFINITIONS
1515
ADMINISTRATOR INTERFACE
1516
INFOFRAME VIEWER
1517
1402
MANAGER
MANAGER API
1521
FOLDER API
1522
INFOFRAMEREQUEST API
1523
INFOFRAME API
1524
DATA ON CLIENT DISK: FOLDERS, ANALYSTS, INFOFRAMES
1403
SERVER APIs
COMM ROUTINES
METADATA API
1531
INFOFRAME GENERATION API
1532
DATA WAREHOUSE API
1533
SESSION MANAGEMENT API
1534

FIG. 16

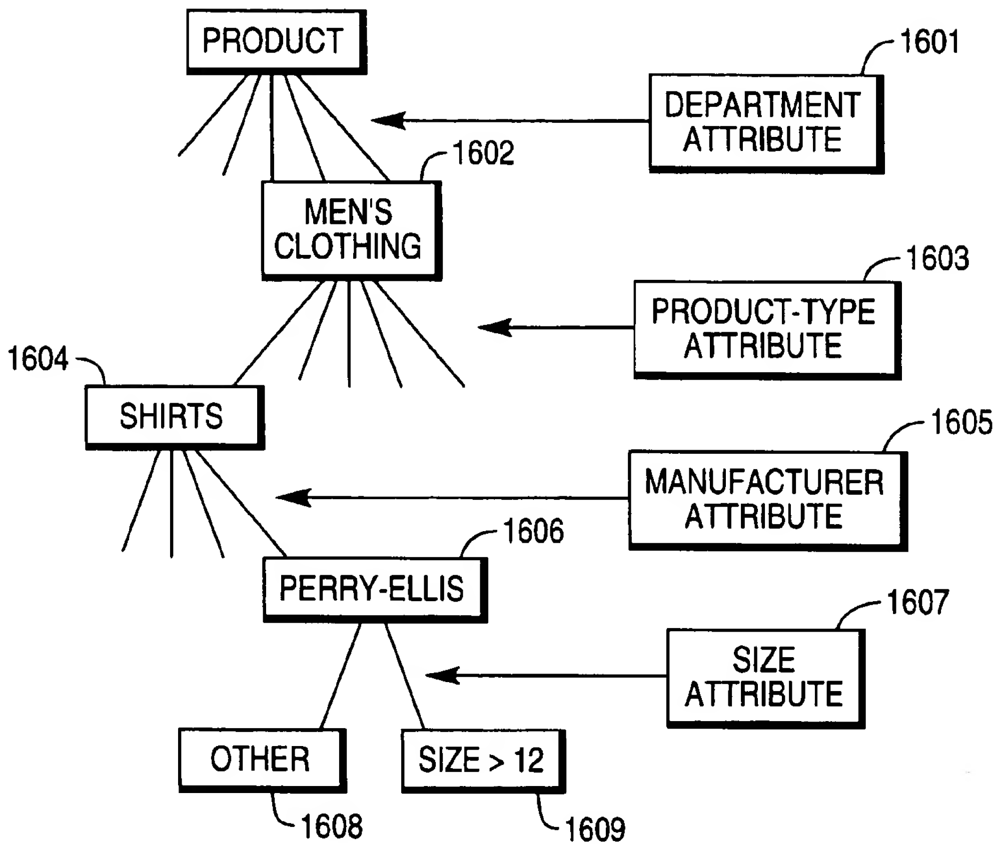

PRODUCT
1601
DEPARTMENT ATTRIBUTE
1602
MEN'S CLOTHING
1603
PRODUCT-TYPE ATTRIBUTE
1604
SHIRTS
1605
MANUFACTURER ATTRIBUTE
1606
PERRY-ELLIS
1607
SIZE ATTRIBUTE
OTHER
SIZE > 12
1608
1609

FIG. 17

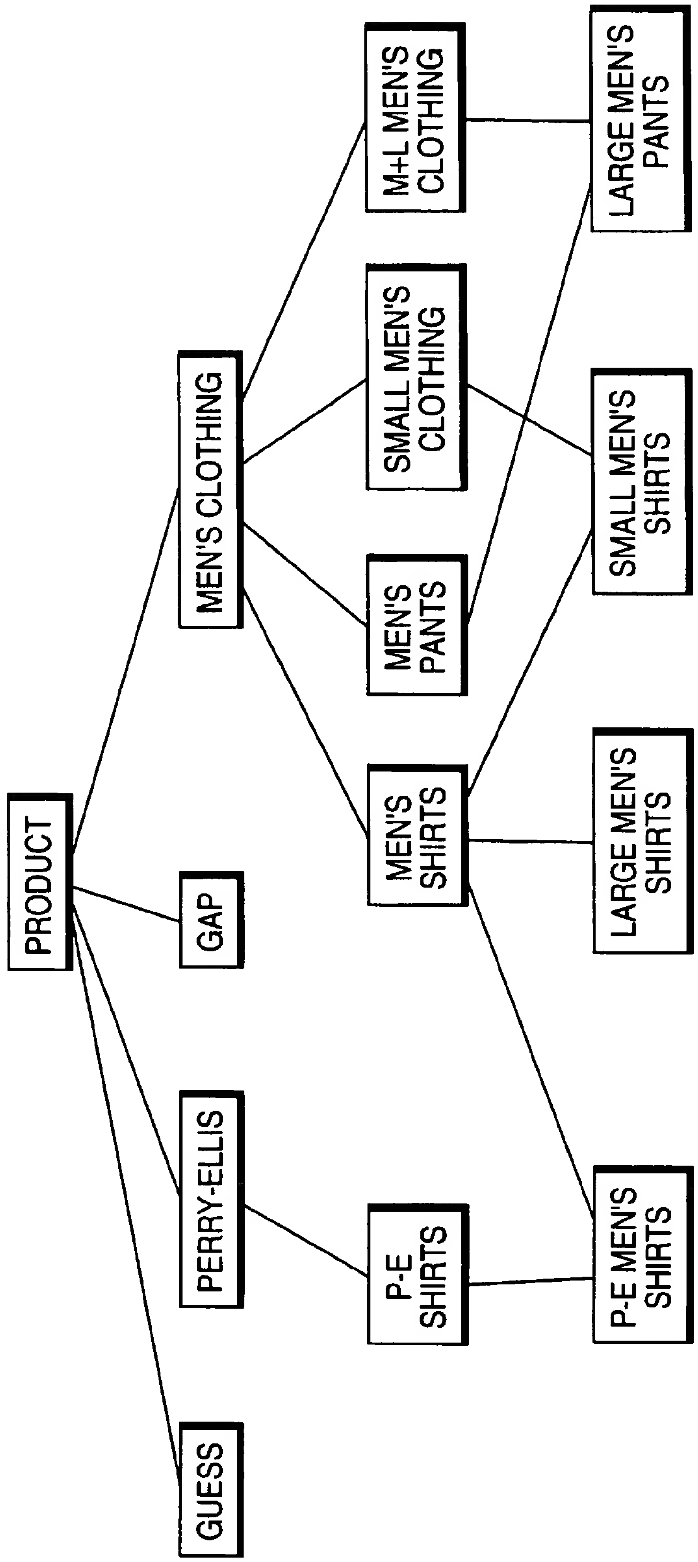

PRODUCT
GAP
PERRY-ELLIS
GUESS
MEN'S CLOTHING
M+L MEN'S CLOTHING
SMALL MEN'S CLOTHING
MEN'S PANTS
MEN'S SHIRTS
P-E SHIRTS
LARGE MEN'S PANTS
SMALL MEN'S SHIRTS
LARGE MEN'S SHIRTS
P-E MEN'S SHIRTS

FIG. 18

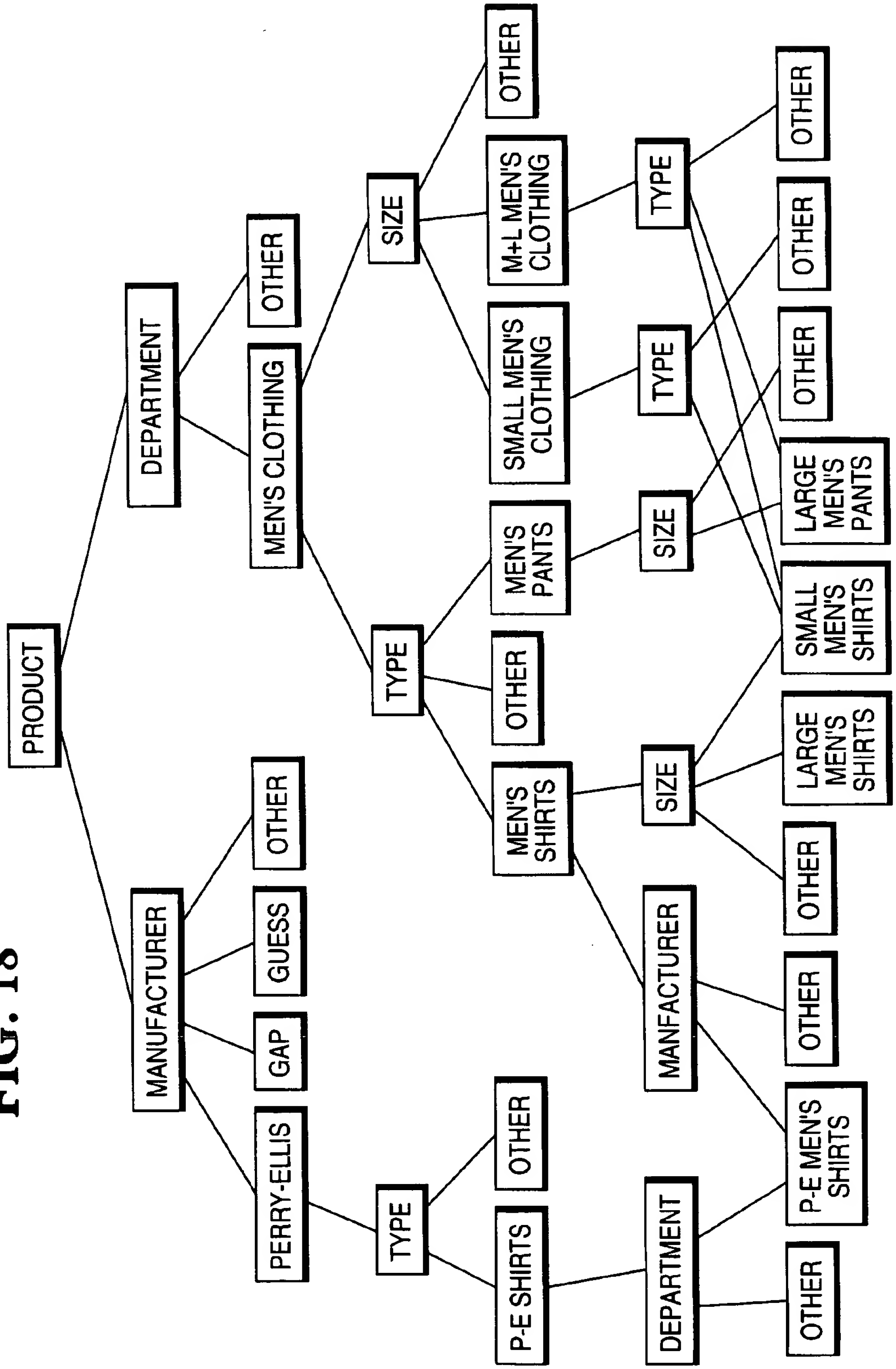

PRODUCT
DEPARTMENT
MANUFACTURER
OTHER
MEN'S CLOTHING
GUESS
GAP
PERRY-ELLIS
SIZE
TYPE
OTHER
M+L MEN'S CLOTHING
SMALL MEN'S CLOTHING
MEN'S PANTS
MEN'S SHIRTS
P-E SHIRTS
SIZE
MANFACTURER
DEPARTMENT
LARGE MEN'S PANTS
SMALL MEN'S SHIRTS
LARGE MEN'S SHIRTS
P-E MEN'S SHIRTS

FIG. 19

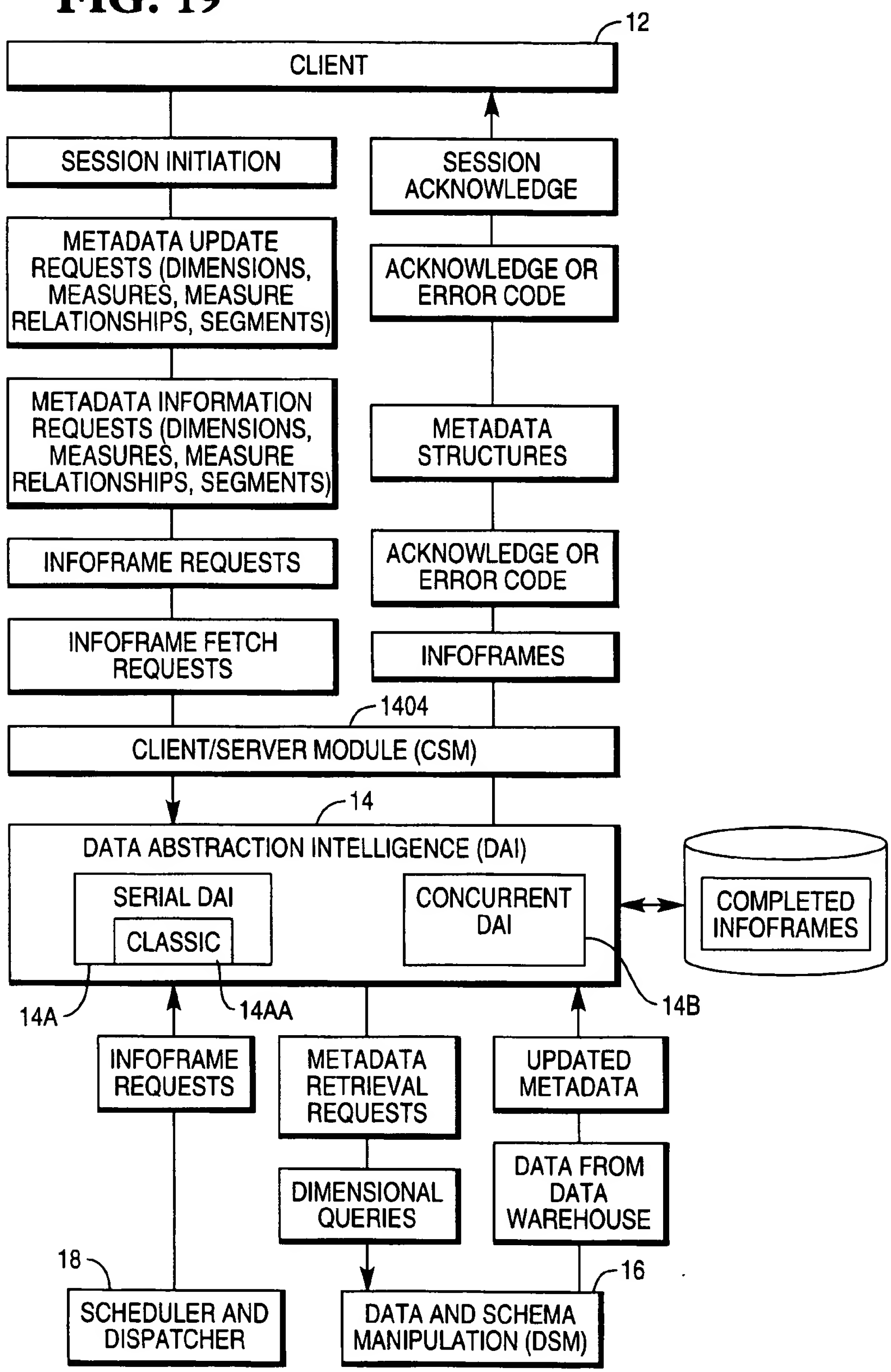

12
CLIENT
SESSION INITIATION
SESSION ACKNOWLEDGE
METADATA UPDATE REQUESTS (DIMENSIONS, MEASURES, MEASURE RELATIONSHIPS, SEGMENTS)
ACKNOWLEDGE OR ERROR CODE
METADATA INFORMATION REQUESTS (DIMENSIONS, MEASURES, MEASURE RELATIONSHIPS, SEGMENTS)
METADATA STRUCTURES
INFOFRAME REQUESTS
ACKNOWLEDGE OR ERROR CODE
INFOFRAME FETCH REQUESTS
INFOFRAMES
1404
CLIENT/SERVER MODULE (CSM)
14
DATA ABSTRACTION INTELLIGENCE (DAI)
SERIAL DAI
CLASSIC
CONCURRENT DAI
COMPLETED INFOFRAMES
14A
14AA
14B
INFOFRAME REQUESTS
METADATA RETRIEVAL REQUESTS
UPDATED METADATA
DIMENSIONAL QUERIES
DATA FROM DATA WAREHOUSE
18
16
SCHEDULER AND DISPATCHER
DATA AND SCHEMA MANIPULATION (DSM)

FIG. 20

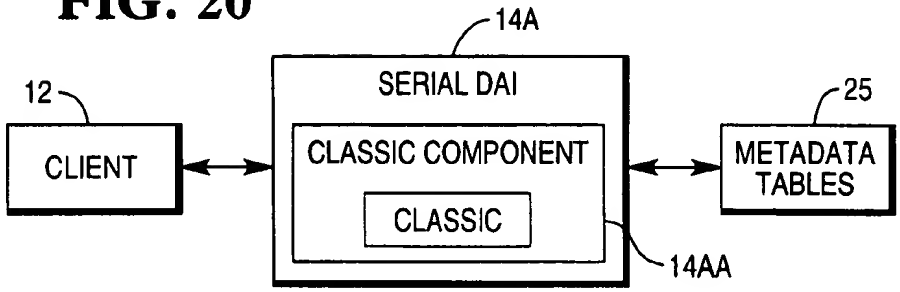


FIG. 21

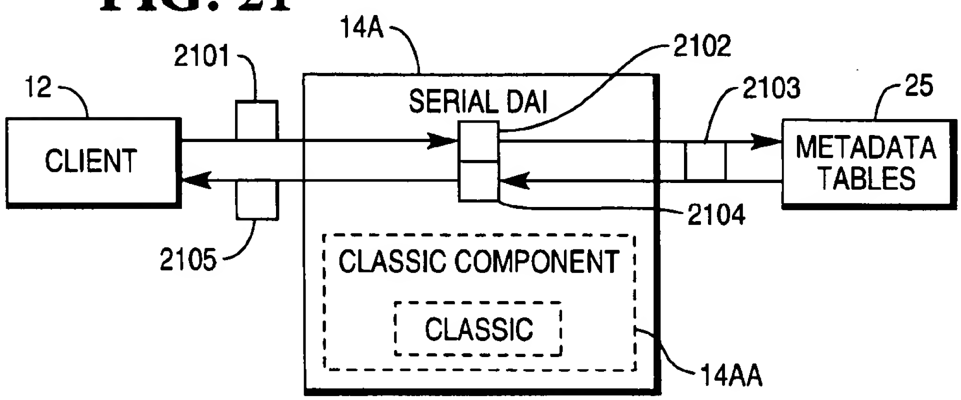


FIG. 22

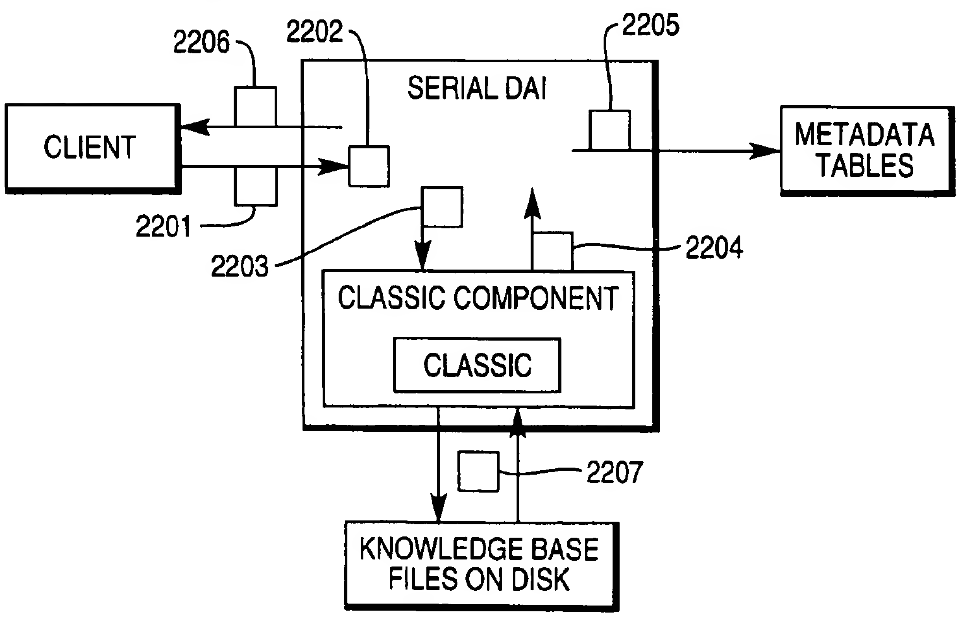


FIG. 23

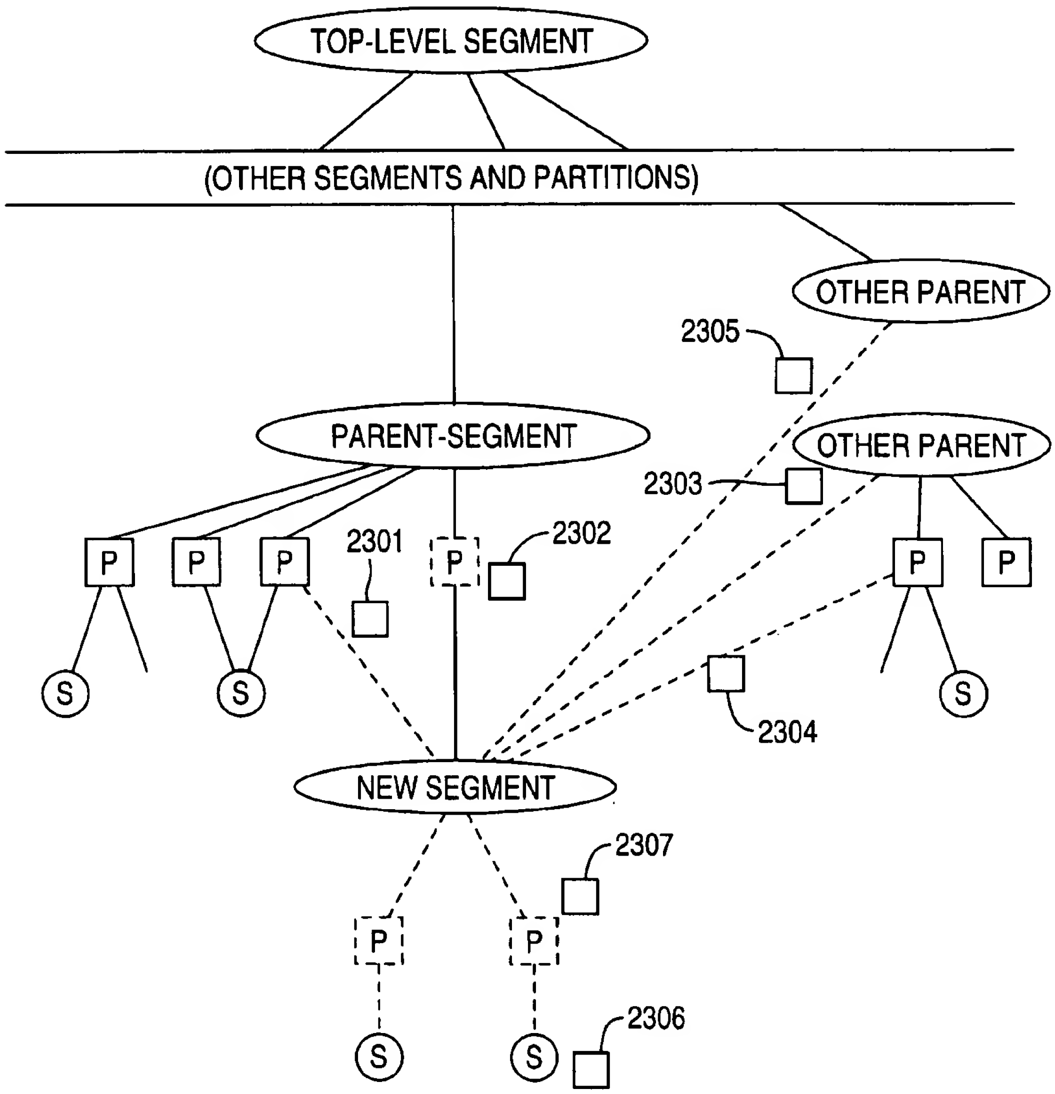

TOP-LEVEL SEGMENT
(OTHER SEGMENTS AND PARTITIONS)
OTHER PARENT
2305
PARENT-SEGMENT
OTHER PARENT
2303
P
P
P
2301
P
2302
P
P
S
S
S
2304
NEW SEGMENT
2307
P
P
S
S
2306

FIG. 24

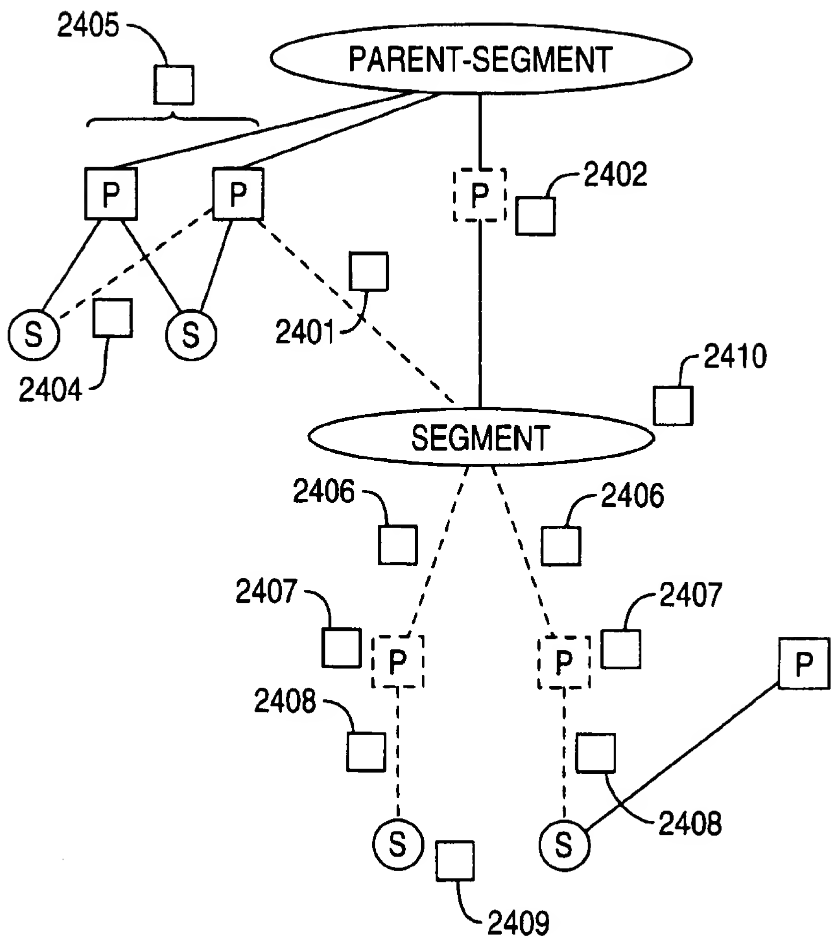
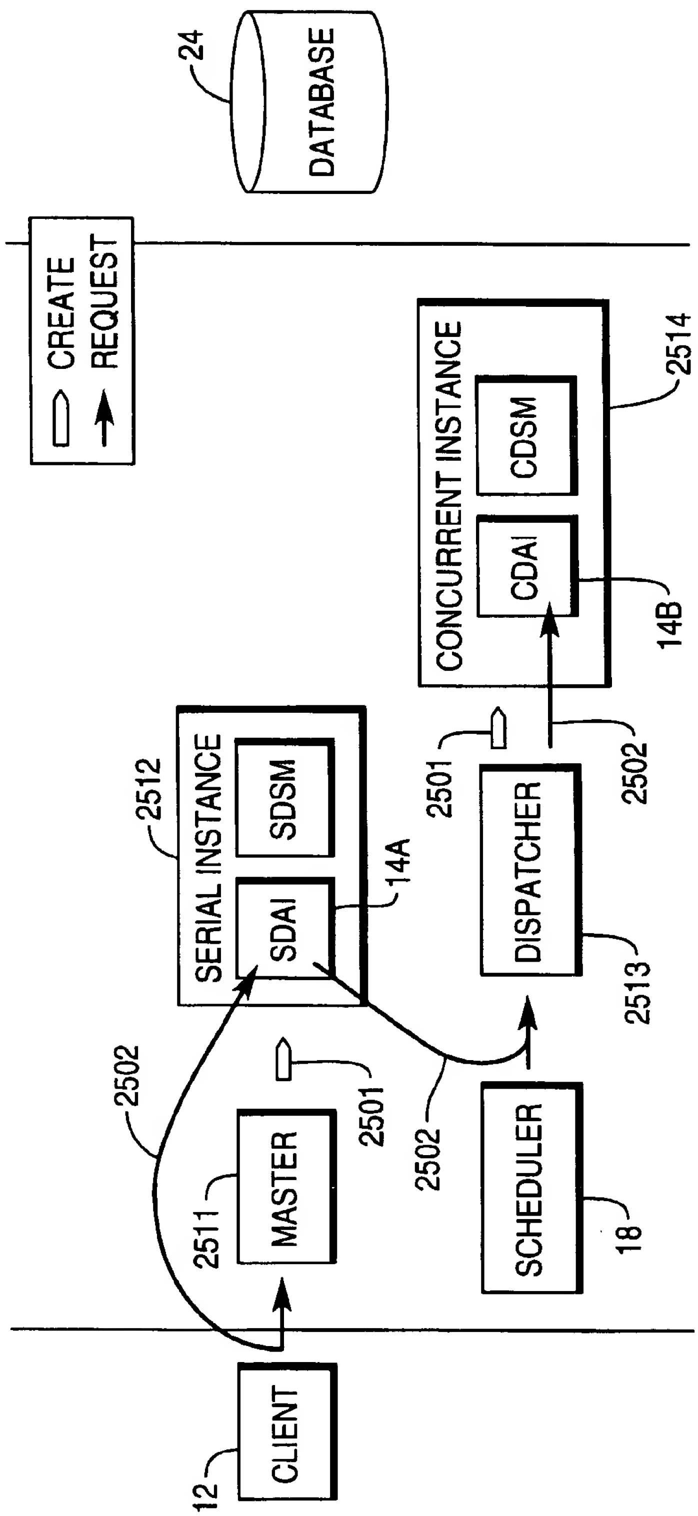

2405
PARENT-SEGMENT
P
P
P
2402
S
S
2401
2404
2410
SEGMENT
2406
2406
2407
2407
P
P
P
2408
2408
S
S
2409

FIG. 25



DATABASE
24
CREATE
REQUEST
CONCURRENT INSTANCE
CDSM
CDAI
2514
14B
SERIAL INSTANCE
SDSM
SDAI
2512
14A
DISPATCHER
2501
2502
2513
MASTER
2511
SCHEDULER
18
CLIENT
12

FIG. 26

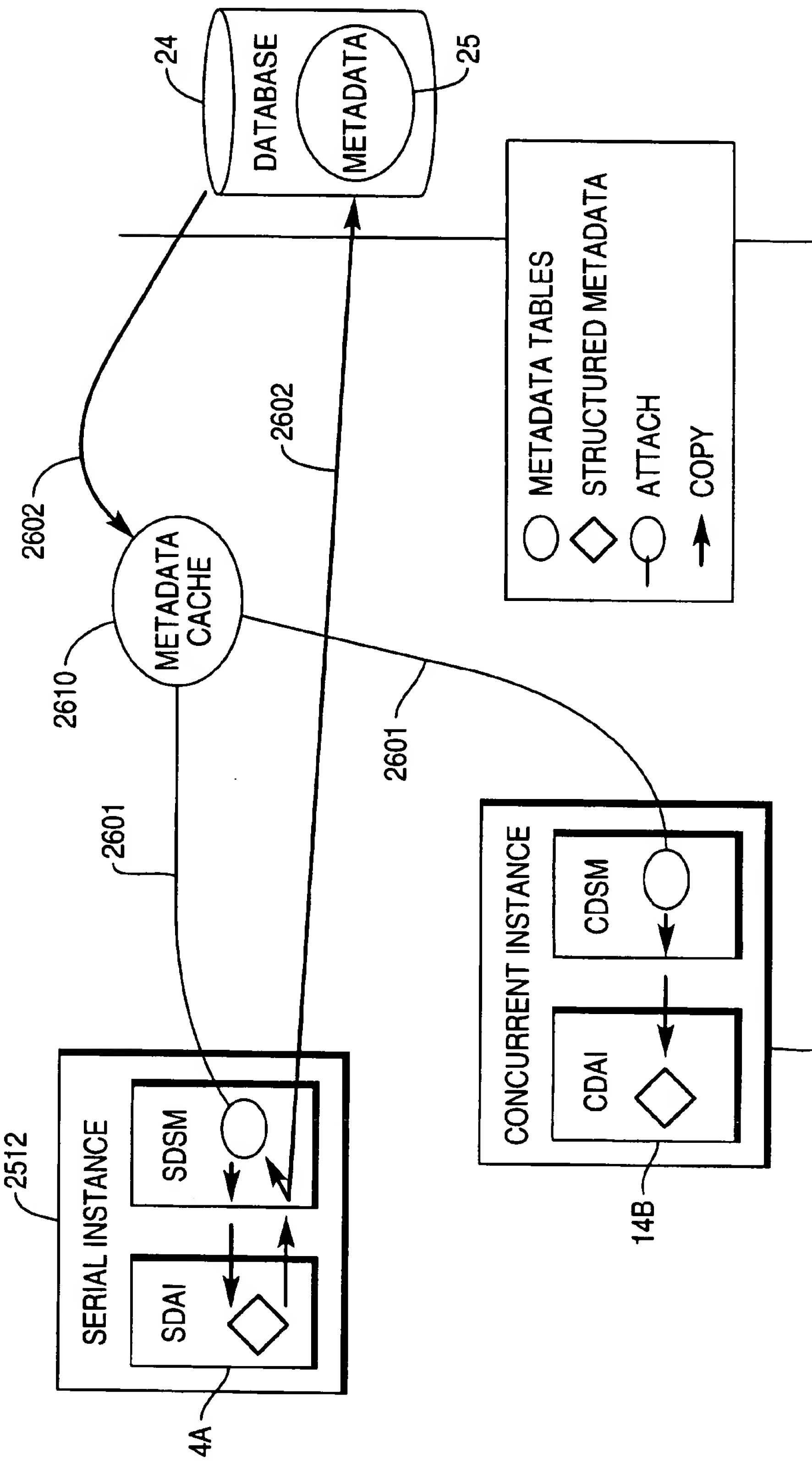
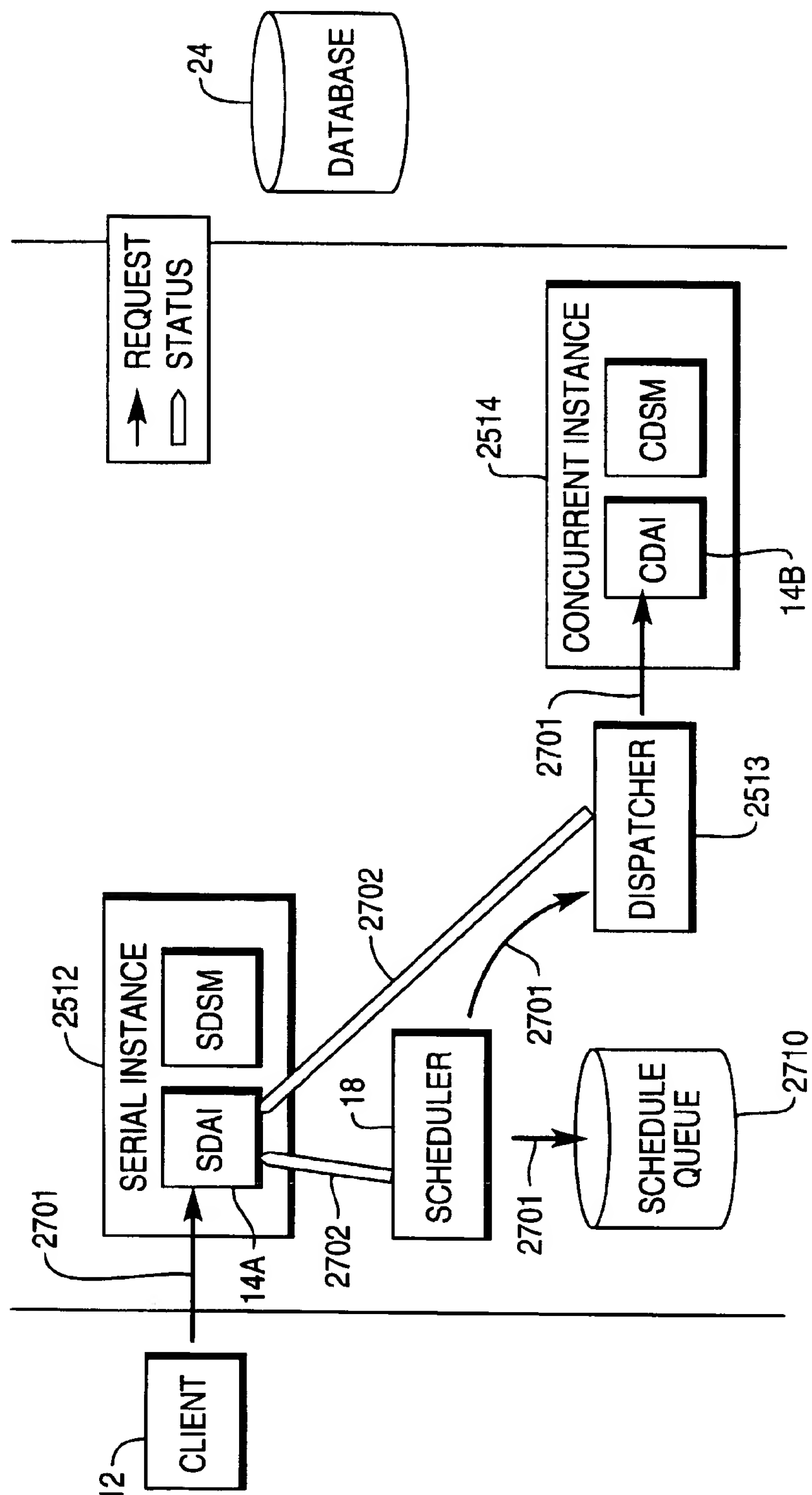
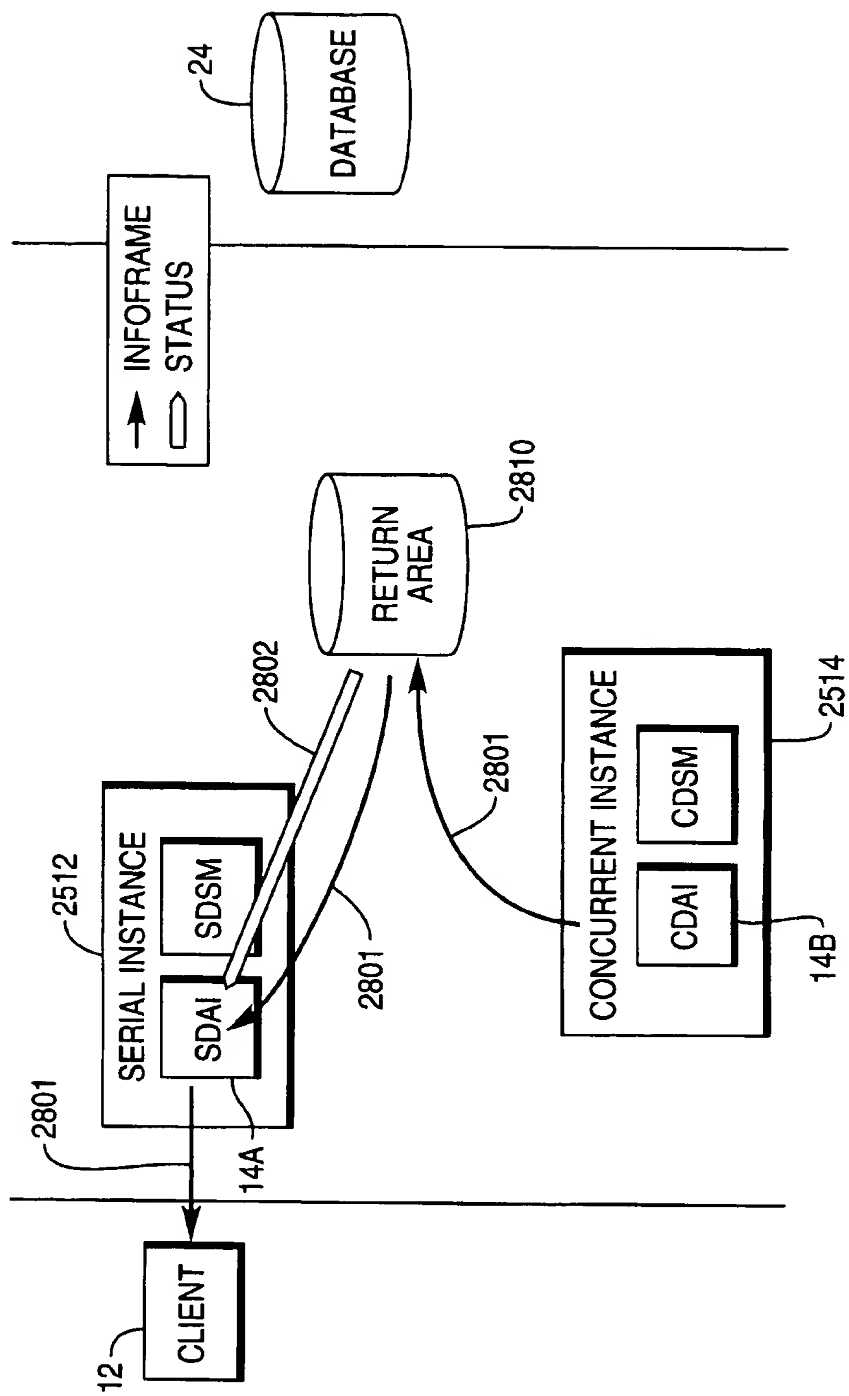

DATABASE
METADATA
24
25
METADATA TABLES
STRUCTURED METADATA
ATTACH
COPY
2602
2602
METADATA CACHE
2610
2601
2601
SERIAL INSTANCE
SDSM
SDAI
2512
14A
CONCURRENT INSTANCE
CDSM
CDAI
2514
14B

FIG. 27



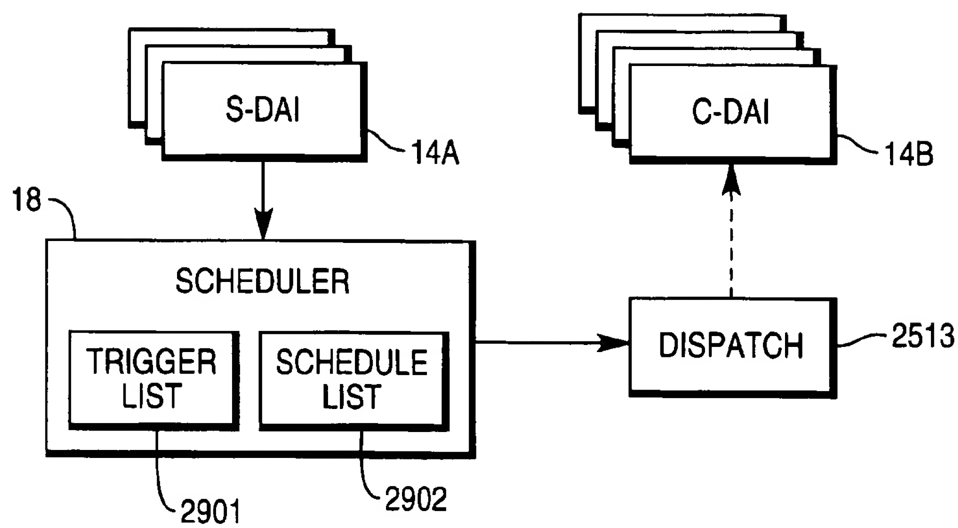
DATABASE
24
REQUEST
STATUS
CONCURRENT INSTANCE
CDAI
CDSM
2514
14B
2701
DISPATCHER
2513
2702
SERIAL INSTANCE
SDAI
SDSM
2512
SCHEDULER
18
SCHEDULE QUEUE
2710
2701
2702
14A
CLIENT
12

FIG. 28



DATABASE
24
INFOFRAME
STATUS
RETURN AREA
2810
2802
2801
SERIAL INSTANCE
2512
SDSM
SDAI
14A
2801
2801
CONCURRENT INSTANCE
2514
CDSM
CDAI
14B
CLIENT
12

FIG. 29


S-DAI
14A
C-DAI
14B
18
SCHEDULER
TRIGGER LIST
SCHEDULE LIST
DISPATCH
2513
2901
2902

SYSTEM AND METHOD FOR SEGMENTING A DATABASE BASED UPON DATA ATTRIBUTES

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is a continuation-in-part of U.S. patent application Ser. No. 08/542,266, filed Oct. 12, 1995, and entitled "System and Method For Generating Reports From a Computer Database", now abandoned. This patent application is also related to co-pending U.S. patent application Ser. No. 08/742,006, filed Oct. 31, 1996, and entitled "System And Method For Performing Intelligent Analysis Of A Computer Database", now U.S. Pat. No. 5,832,496, and Ser. No. 08/742,003, filed Oct. 31, 1996, and entitled "Hypertext Markup Language (HTML) Extensions For Graphical Reporting Over An Internet" now U.S. Pat. No. 5,748,188.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to expert systems and reporting systems, and more specifically to a system and method for generating reports from a computer database.

2. Description of the Prior Art

Storing large amounts of transaction-level data for later analysis (data warehousing) is becoming recognized as an enabler for businesses that are seeking a competitive advantage. Tightening competitive environments and global economic trends are forcing businesses and entire industries to search for a means to gain an advantage. This advantage can be realized through the use of strategic data relating to their business—allowing better and more timely decisions, leading to a better understanding of their business and support for their customers, that ultimately leads to growth. To make use of data warehouses, the data must be retrieved, organized and then presented in an understandable format.

Discovery tools are used to retrieve, analyze and present data from data warehouses. These tools can range from very complex modeling tools to relatively simple end user query tools designed to do no more than mask the complexity of the SQL database programming language from the user. Automated tools that search the data for trends or relationships are also considered discovery tools.

The marketplace is comprised of various tool vendors whose products provide solutions for a portion of the entire knowledge discovery process. Therefore, to effectively utilize their data, the user community is forced to pick multiple, disjointed tools. In addition, these tools are targeted toward the expert user who has an in-depth knowledge of the data and database formats or the various analytic methods that are implemented in the tool. Existing products also do not let the business user explicitly and iteratively represent business knowledge. Finally, the output of existing tools consists of tables of numbers that users have to analyze and interpret.

Data warehouses, and databases in general, typically have complex structure organized for efficiency of data retrieval, not ease-of-use by the end user. Users, especially business users, desire reports in their vocabulary, not the vocabulary of the database. While some tools in the marketplace allow a user to define new terms and map those terms to the database, the management of related sets of new terms is not supported. That is, the relationship of a new term to existing terms is not automatically detected for the user.

In addition to these difficulties, it is common for the contents of a report to cause a user to desire another, similar report. Saving and re-using sets of related reports (re-generating the reports over a new set of data) is also desired. The generation of related reports and the re-generation of reports over new data is a capability not adequately available in the marketplace.

Therefore, it would be desirable to provide a system and method for generating reports from a computer database which allow a user to retrieve and analyze data with one tool without requiring the user to have knowledge of underlying data structures or of the SQL database programming language, which allow a user to define new terms and detect and manage relationships between terms, which allow a user to easily generate related reports, and which allow a user to re-run sets of related reports over new data. It would also be desirable to provide a system and method for allowing the a user to segment and partition a database based upon attributes associated with the data in the database.

SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention, a system and method for generating reports from a computer database are provided. A system and method for allowing a user to segment and partition a database based upon attributes associated with the data in the database are also provided.

A database computer includes a database containing the data. The data includes a collection of information about an enterprise of the user. A server computer is coupled to the database computer and executes a database management program. A client computer is coupled to the server and executes a metadata management and SQL generator program. The application program allows a user to define predetermined data types, to define relationships between the data types, to define parameters for the report, to define a method of analysis for the report, and to create the report. The report summarizes the data in terms of the data types, the data relationships, and the method of analysis.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the system of the present invention;

FIG. 2 is a block diagram of a client subsystem within the system of FIG. 1;

FIG. 3 is a block diagram of a data abstraction intelligence subsystem within the system of FIG. 1;

FIG. 4 is a block diagram of a data and schema manipulation subsystem within the system of FIG. 1;

FIG. 5 is a block diagram of a scheduler subsystem within the system of FIG. 1;

FIGS. 6–12 are views of a tool for creating reports which employs a graphic user interface;

FIG. 13 is a flow diagram illustrating how metadata is created.

FIG. 14 is another block diagram of a client subsystem within the system of FIG. 1.

FIG. 15 is yet another block diagram of a client subsystem within the system of FIG. 1.

FIG. 16 is a database heirarchy that may be created according to the teachings of the present invention.

FIG. 17 is another heirarchy that may be created according to the teachings of the present invention.

FIG. 18 is yet another heirarchy that may be created according to the teachings of the present invention.

FIG. 19 is a general, high-level data flow between the DAI and the other subsystems and components of the system of the present invention.

FIG. 20 is an architecture of a Serial DAI subsystem of FIG. 1.

FIG. 21 is a flow diagram for the Serial DAI system of FIG. 1.

FIG. 22 is another flow diagram for the Serial DAI system of FIG. 1.

FIG. 23 is a depiction of the addition of a database segment in the system of the present invention.

FIG. 24 is a depiction of the deletion of a database segment in the system of the present invention.

FIG. 25 is a description of the processes performed by the server of FIG. 1.

FIG. 26 is a diagram showing the relationships and operations with respect to metadata.

FIG. 27 is a diagram showing the relationships and operations with respect to the scheduler queue.

FIG. 28 is a diagram showing the relationships and operations with respect to the return area.

FIG. 29 is a diagram depicting the requests performed by an analyst.

DETAILED DESCRIPTION OF THE INVENTION

1. Overview of Basic Invention

Referring now to FIG. 1, system 10 includes four major subsystems: client subsystem 12, data abstraction intelligence (DAI) subsystem 14, data and schema manipulation (DSM) subsystem 16, and scheduler subsystem 18.

In connection with the description of system 10, the following definitions are provided:

An Alert Condition is a user-defined condition or set of conditions that when satisfied returns an Alert Message. For instance, an Alert Condition may be defined so that when the inventory of brand A shirts drops below 200 units for a given week, system 10 produces an Alert Message, InfoFrame or runs another analyst.

An Alert Message is a message that notifies the user that an Alert Condition has been satisfied. From an Alert Message the user can select the corresponding InfoFrame to be run. An example of an Alert Message would be "Alert: the inventory of brand A shirts is below 200."

An Alert InfoFrame is a type of InfoFrame that describes an Alert Message in detail. The Alert InfoFrame has a description of what happened, when, and probable reasons why it occurred.

An Analyst specifies an event in the data which must trigger an Alert; or specifies the type of analysis and the business measures and segments to be reported on in an InfoFrame, and optionally the schedule on which this InfoFrame is to be generated or the event in the data which must trigger the InfoFrame.

An attribute is a characteristic or feature of an entity represented in the warehouse. For example, Color, Manufacturer, or Size are all attributes of the product category of Clothing.

(10)

An attribute restriction is an expression that restricts the value that attribute can have. For example, in "Price is less than $10.00", the "less than $10.00" is a restriction on the Prices attribute. Another example might be: "Woman's Clothing or Men's Clothing" is a restriction on the Department Attribute. A single attribute value, like "Blue" or "Men's Clothing", is also an attribute restriction.

A specific entity (like a product) in the data warehouse is represented as a set of attributes and values. For example, the product "Perry Ellis men's shirt, size 42, color blue", might be represented as "Product: Department: Men's Clothing; Manufacturer: Perry Ellis; Size: 42; Color: blue". These values are members of a specific domain for each attribute (see below).

Business Indicators are classifications across Business Concepts that are usually related to numerical values (e.g. Sales Volume, Inventory, Price). Business indicators have methods and formulae that pertain to their computation (e.g. Total Sales) and causal associations between Business Indicators (e.g. If Price increases Sales Volume should decrease). Within a Business Indicator, segments can be defined which describe a specific group of Business Indicators of interest (e.g. Senior Customer, Company A Products).

A Change Analysis Report is a compound document describing Business Indicators over two time periods. Within system 10, one can specify two periods of time and see the difference of a chosen Business Indicator for that period (e.g., How did this year's sales of textiles compare to last years sales?) Change Analysis Reports can report results for a day, week, month, quarter, year, or other defined period.

A Comparison Analysis InfoFrame is a type of InfoFrame helps a business user compare the value of two Business Indicators across the same time period or compare the value of the same Business Indicator across two sibling segments across the same time period.

Compound Business Indicators are user-defined Business Indicators created by combining primitive Business Indicators with arithmetic and set operations.

A Data Warehouse is a very large collection of data that is housed in one or more databases. These databases usually reside on database server computers and can be either in one location or distributed geographically.

A Dimension defines the high-level categories of entities. For example, in a Retail domain, the dimensions might be: Product, Market, and Time (Time is a universal dimension applicable to any domain). A dimension has associated with a set of attributes that can be used to describe its entities; for example, Brand, Manufacturer and Size describe the dimensions of a product.

Every attribute has an implicit or explicit domain of values. For example, the domain of values for the Department attribute is an encoding of the legitimate departments for the enterprise, and the domain of values for the Size attribute is a non-zero number representing the size in specified units.

A Drill Down Heuristic specifies some relation between the measure values of the segments of a free attribute of a segment which must be reported to the user.

End Users are users for which system 10 is specifically designed. End users typically have knowledge of a business' operations and for this example have used Microsoft Windows (Windows 3.1, Windows NT & Windows 95, etc.). End users typically do not have expertise in SQL code generation or the specific data structures of the databases they want to access.

Enterprise Information Factory (EIF) is a commercial software package that allows typical business users to access their data warehouse data. The data warehouse is essentially a passive environment that usually requires the use of SQL code and knowledge about the structure of the database to access data. The EIF differs from the data warehouse by providing a foundation for providing tools to allow users without SQL or database knowledge to get data out of their databases.

An Exception Analyst is specifically an Analyst which runs regularly to test for a trigger condition, and which returns an Alert or a Report when the trigger condition occurs.

If the domain of an attribute is a finite set (like Department above), it is called a finite domain. The alternative is an infinite or continuous domain, like Price.

A Free Attribute is an attribute of a segment which has not been restricted to define that segment. Color, Cost, and Weight might all be free attributes of the segment "Expensive Shirts"

A Heuristic Rule specifies some condition of data, some relation between the segment measure values found by an analyst, that should be reported to the user in the completed InfoFrame.

HyperText Markup Language (HTML) is an emerging standard format for software documents that allows for the inclusion of hyperlinks and graphics (pictures, graphs, tables) in text documents. A hyperlink is a "hot" area in the document (usually text in a different color than the surrounding text), that when clicked on, shows another document that is related or linked to the original HTML document.

InfoFrame Definitions are System Templates that have been customized to include particular Business Concepts, Business Indicators, Time Intervals, Analysis Type, and segments. InfoFrame Definitions can be immediately "run" to produce a "InfoFrame", saved to be run later, saved and scheduled to be run later, or triggered by another analyst.

A Knowledge Worker is typically a person familiar with SQL, who knows the structure of the Data Warehouse and who has an analytical background. In addition, the Knowledge Worker may use statistical and data analysis packages and data modeling tools.

(30) Managament Discovery Tool (MDT) refers to the overall system of the present invention.

Metadata is the collection of information about the end user's particular business, and may be one of three types: core, public or private. After installation this information is stored in the end user's database and is used to tailor reports to the end user's particular business needs. Metadata includes, but is not limited to, Business Concepts, Business Indicators, Segments, Attributes, Attribute Values and Measure Relationships.

The core set of metadata is typically set up at installation by professional services personnel and the MDT Administrator. Core metadata consists of Dimensions, Attributes, Basic Measures, Segments and Year definitions.

Public metadata is only changeable by the MDT Administrator and Knowledge Worker user types and is defined and modified after installation. Public metadata includes Public Composite Measures, Public Measure Relationships and Public Segments.

Private metadata belongs to each user and is only changeable by the end user (Business/executive user) user type. Private metadata includes Private Composite Measures, Private Measure Relationships and Private Segments.

If an attribute has a finite domain, the Natural Partition is the partition where each segment corresponds to each element of the domain. For example, the natural partition of the Department attribute is the set of segments "Men's Clothing", "Woman's Clothing", etc.

Object Linking and Embedding (OLE) is a computer format that allows objects (e.g., graphs, tables) in computer documents to, when double clicked on, bring up the software application that created the object (graph, table, document).

If the user-defined segments for a given partition do not cover the domain, then an "Other" segment will stand for the rest of the partition.

A partition is an implicit or explicit division of the dimension by the restriction of a single attribute. For example, of one takes the Price attribute, and the "less than $10.00" restriction, this defines a partition of products into two sets or segments: those products with Price less than ten dollars, and those products with Price greater to or equal to ten dollars. Note that the sets or segments of a partition must cover the original set and not overlap, i.e., "Price <$10.00" and "Price <$15.00" do not define a partition.

Primitive Business Indicators are Business Indicators that are directly mappable to data in the data warehouse. They are set up during installation of the present invention and are not changeable by the end user.

Reports or InfoFrames are compound documents that display data from a database in text and graphics (e.g., graphs, tables). Reports are the result of running a InfoFrame Definition. InfoFrames may be in the HTML format and may be OLE 2.0 compliant.

A Restricted Attribute is an attribute of a segment which has be restricted to defined the segment. Product and Price might be the restricted attributes of "Expensive Shirts"

Segments are user-defined groups that are defined within a Business Concept having a meaningful attribute or attributes in common. For instance, the segment "Senior Customers" might be those customers whose age is greater than 65 years.

A segment is one part of a partition. Actually, a segment is a subset of data defined by restrictions on one or several attributes. If a segment is defined by several attributes, it can be part of several partitions, one for each restricted attribute (as shown shortly. This means that, given a segment in isolation, one cannot determine which partition it "should" belong to, and thus, one cannot determine its natural parents in the hierarchy).

A set of segments forms a segment hierarchy under the subset relation, with a root that is the "top-level segment", which contains all of the members of the dimension.

Structured Query Language (SQL) is a structured language for viewing the contents of a relational database.

Summarization InfoFrame is a type of InfoFrame that shows a roll-up or summarization of a specified Business Indicator across one or more specified segments. By selecting a particular Business Indicator in this report a InfoFrame showing the "winners" and "losers" for the specified period can be automatically produced.

System Administrators (MDT Administrators, or MDTA) are those users of system 10 who have an intimate knowledge of the databases and data structures of an organization. Often the System Administrator has the title of "database administrator" (DBA).

A Text Generation Rule specifies the text that must be inserted into an InfoFrame when the some heuristic rule is satisfied.

A Trend Analysis InfoFrame is a type of InfoFrame that, when defined, shows the trend for a specific Business Indicator or indicators over a specified period of time. This analysis can aid in forecasting the future by identifying patterns in past activities. (49)

Client subsystem 12 is a single application program which has a graphical user interface (GUI) 40 and which allows a user to select and specify parameters for InfoFrames, view InfoFrames, print InfoFrames, and save InfoFrames. Finally, the user can define Composite Business Indicators and Segments, create Analysts, define Measure Relationships, or modify the schedule of Analysts.

DAI subsystem 14 provides intelligent middleware for translating graphical user requests, selecting system templates, manipulating data views, and generating dimensional queries for retrieving data from data warehouse 24. It also contains rules for choosing default parameters, for

choosing layout and display formats, and for generating text from data. DAI subsystem 14 is responsible for instantiating user selected InfoFrames and managing several kinds of metadata 25 used in this instantiation. This metadata 25 represents Business Concepts and Business Indicators that provide a customizable "dimensionalization" of the relational data in data warehouse 24. DAI subsystem 14 also processes updates to this metadata 25 that originate in client subsystem 12 and handles several other kinds of user updates, primarily by passing them to DSM subsystem 16.

DSM subsystem 16 reads schema from data warehouse 24, creates data views, and creates a mapping between the two. It also uses that mapping to translate the Dimensional Queries received from DAI subsystem 14 into SQL and package and return the results.

Scheduler subsystem 18 is responsible for for starting Analysts which are to run at a scheduled time or on a regulare schedule; or Exception Analysts which must regularly test for a trigger condition in the database. When the requested time interval occurs, the Scheduler starts up, requests a list of scheduled InfoFrame Requests from DAI subsystem 14. From those lists, scheduler subsystem 18 determines which should be run during the current time interval and sends those requests to DAI subsystem 14 as if they were sent by client subsystem 12.

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Thus, system 10 is implemented as a three-tier architecture. Client computer 30 executes client subsystem 12. Client computer 30 preferably executes Windows NT, or Windows 95, although other operating systems are also envisioned by the present invention. Client subsystem 12 (FIGS. 6–12) is suitable for use with these operating systems. Display 22 and input device 21 allow a user to view GUI 40 and enter choices of metadata 25 used in creating Analysts. Input device 21 may be a keyboard, mouse, or other pointing device. Printer 23 allows a user to print a InfoFrame. Storage medium 26 allows a user to store an InfoFrame or Alert Message.

Server computer 32 executes DAI subsystem 14, DSM subsystem 16, and scheduler subsystem 18. These three subsystems combine to satisfy user requests from client subsystem 12 using information from data warehouse 24. Server computer 32 is preferably a multi-processor computer and executes the UNIX operating system or Windows NT, although other computer and operating system configurations are also envisioned by the present invention.

Client and server computers 30 and 32 are preferably coupled asynchronously for report requests; all other requests are satisfied synchronously. Communication between client and server computers 30 and 32 is preferably through transmission control protocol/internet protocol (TCP/IP), although other transmission protocols are also envisioned by the present invention.

Database computer 34 includes one or more storage media 36 containing data warehouse 24. Database computer 34 is preferably a massively parallel processor computer and executes the UNIX operating system or Windows NT, although other computer and operating system configurations are also envisioned by the present invention. Data warehouse 24 is suited to run on any computer which supports an Open Database Connect (ODBC) interface to data warehouse 24. Communication between server computer 32 and database computer 34 is preferably via ODBC, although other database interfaces are also envisioned by the present invention.

Turning now to FIG. 2, client subsystem 12 is an application program which gives a user control over system 10 and is suitable for execution on top of the Windows NT, or Windows 95 operating systems. Client subsystem 12 includes log-in module 50, folder management subsystem 54, segment builder 55A, measure builder 55B and measure relationship builder 55C, analyst definition subsystem 56, InfoFrame viewing subsystem 53 and MDT Administrator interface 57.

Log-in module 50 verifies that only one copy of the client subsystem 12 is running on computer 30, checks the localization of computer 30, connects to computer 32, and interacts with the user to log him onto client subsystem 12. During logon, log-in module 50 verifies a user's name and password and then retrieves any user preferences that may have been earlier defined. The only request from a user that is handled by log-in module 50 is a request to log onto client subsystem 12.

Log-in module 50 issues the following requests:

• single program running	to Operating System (DOS, NT, Windows 95, etc.)
• retrieve localization	to Operating System (DOS, NT, Windows 95, etc.)
• connect to server	to Client/Server module
• disconnect from server	to Client/Server module
• authenticate user	to Metadata API 60
• run main menu	to Main Menu 51
• run admin menu	to MDT Administrator Interface 57

If the user is the System Administrator, log-in module 50 displays MDT Administrator interface 57 "Setup" menu item. If the user is an end user or knowledge worker, a Main menu and toolbar interface 51 are displayed, as are the interfaces associated with subsystems 53–55.

MDT Administrator interface 57 is used by a System Administrator to perform system administration tasks, such as making user-defined segments available globally and creating and editing Business Concepts. Interface 62 is preferably only available to System Administrators during system installation.

Folder management subsystem 54 handles all functions related to manipulating, storing, and retrieving Folder hierarchies, and the InfoFrames and Agents that are stored in those Folders. It also handles querying from DAI subsystem 14 for newly-completed InfoFrames, both when client subsystem 12 starts up, and then periodically thereafter.

Folder management subsystem 54 also handles User requests for operations on:

Folders (new, delete, rename)

Agents (edit, delete, run now, print)

InfoFrames (view, delete, annotate, print [in cooperation with the InfoFrame View Window])

Each folder is represented by one folder object. A folder stores a list of child folders, a list of InfoFrames, and a list of Agents. Folder objects are created and deleted by folder management subsystem 54 in response to user requests.

Subsystems 55B provides a user with the ability to create new measures, update measures, or delete existing measures. This information is sent to a Metadata API 60 and thereafter to DAI subsystem 14 for updating the user's Metadata 25.

Subsystem 55A provides a user with the ability to create new Segments, update segments, or delete existing Segments. This information is sent to a Metadata API 60 and thereafter to DAI subsystem 14 for updating the user's Metadata 25.

Finally, Subsystem 55C provides a user with an interface to modify measure relations and to constrain measure relations. The user selects the current measure and whether to

evaluate that measure's relationships when it increases or decrease. Then the user can then select from a list of other measures and define their relationship to the current measure. These relationships are in the form of "decreases", "increases", or "is unrelated to the current measure". Also, every relationship between two measures can be constrained. The relationship between measures and the constraints placed upon them are saved on computer 32 for use in generating InfoFrames.

Analyst definition subsystem **56** handles all functions related to user selection of parameters needed to generate specific reports. It also allows the user to define and schedule Alerts for scheduled reports.

The user may invoke an existing Analyst, delete one from within the folder management subsystem **54**, or create a new Analyst. The five types of Analysts are:

Summarization

Segment Comparison

Measure Comparison

Change Analysis

Trend Analysis

The Summarization Analyst requires the following user selection requirements:

Analyst name

Primary measure, other optional measures

Primary segment, other segments

Time period

Optional schedule

Optional trigger

type of year used

optional trigger event (Alert Message, InfoFrame, Run another analyst)

The Segment Comparison Analyst requires the following user selection requirements:

Analyst name

Primary measure

Primary segment, a comparison segment

Time period

Optional schedule

Optional trigger

type of year used

optional trigger event (Alert Message, InfoFrame, Run another nalyst)

The Measure Comparison Analyst requires the following user selection requirements:

Analyst name

Primary measure, Comparison measure

Primary segment, other optional segments

base time period, comparison time period

Optional schedule

Optional trigger

type of year used

optional trigger event (Alert Message, InfoFrame, Run another nalyst)

The Change Analysis Analyst requires the following user selection requirements:

Analyst name

Primary measure

Primary segment, Other optional segments

base time period, comparison time period

Optional schedule

Optional trigger

type of year used

optional trigger event (Alert Message, InfoFrame, Run another nalyst)

The Trend Analysis Analyst requires the following user selection requirements:

Analyst name

Primary measure

Primary segment, other optional segments.

Time period, Time interval.

Optional schedule

Optional trigger

type of year used

optional trigger event (Alert Message, InfoFrame, Run another nalyst)

The user can save or run the analyst definition. The user is restricted to choosing one Segment from within each Business Concept with the exception of Target Segment, in which case he may select only one segment and more than one child partition of the selected segment. The user may choose to schedule an Analyst or to modify or delete an existing schedule. Unscheduled Analysts will be run when the user commands. Scheduled Analysts will be submitted to the server for execution at a later date or periodic execution.

The user may specify a trigger condition for the Analyst to specify an Exception Analyst. When submitted to the server it will be run regularly to test for its trigger condition, and will return an Alert or an InfoFrame whenever the trigger condition occurs.

The Analyst definition subsystem **56** makes the following requests to the folder management subsystem **54**:

Save	Check if the user has selected the appropriate parameters for the selected analyst. Send a request to the folder management subsystem 54 to save an existing Analyst Definition
Save As	Check if the user has selected the appropriate parameters for the selected analyst. Send a request to the folder management subsystem 54 to save an existing Analyst Definition
Submit	Check if the user has selected the appropriate parameters for the selected analyst. Send a request to the folder management subsystem 54 to submit a report generation

The Analyst definition subsystem also makes the following requests to Metadata API **60**:

Get all Measures	The request will be made to Metadata API 60 each time there is a need for it at the initialization point of a dialog
Get all Business Concepts	The request will be made to Metadata API 60 subsystem each time there is a need for it at the initialization point of a dialog
Get a Business Concept's Partitions	The request will be made depending on a user's selection of a business concept
Get Partitions	The request will be made depending on a user selection of a defined Segment.
Get Segments	The request will be made depending on a user selection of a partition.

InfoFrame viewing subsystem **53** includes a WYSIWYG browser which displays a selected InfoFrame on screen, when InfoFrame viewing subsystem **53** gets a notification from folder management subsystem **54** to view a InfoFrame.

If the user decides to drill down from the current InfoFrame, InfoFrame viewing subsystem **53** notifies the folder management subsystem **54** to send a new report request.

When the user double-clicks on an InfoFrame or chooses "menu item—View" from the File menu Folders, the folder management subsystem **54** notifies the InfoFrame viewing subsystem to view the InfoFrame. When the user clicks on a hypertext to drill down from the current InfoFrame, the InfoFrame viewing subsystem **53** passes the drill down information to the folder management subsystem **54** to send a new report request to DAI subsystem **14**.

InfoFrame viewing subsystem **53** includes a parser which parses the InfoFrame, and extracts the completed report, which is written in HTML. In an HTML file, HTML tags indicate document elements, structure, formatting, and hypertext linking to other documents or resources. The parser then outputs all the information for display. In the current invention, the hyperlink may instance a new Analyst and a new InfoFrame

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The InfoFrame viewing subsystem **53** allows a user to display and format text, tables, and graphs displayed by display **22** based on the information gathered by the parser. A header, a footer, and annotations can be added to a InfoFrame. The user can save the viewed InfoFrame. The user can also save an InfoFrame as a HTML file in either UNICODE or ASCII code format. A saved HTML InfoFrame can be attached to an e-mail to mail out. Any HTML version 3.0 browser, or equivalent, can read the HTML InfoFrame.

Metadata API **60** handles most of the communications between client subsystem **12** and DAI subsystem **14**. These communications involve four basic types of data: metadata **25**, InfoFrames, user profiles, and data warehouse schema. For metadata communication, Metadata API **60** provides the ability to add, delete and update metadata **25**. For InfoFrames, Metadata API **60** provides the ability to request a report, get the status of a report, retrieve a report and cancel a report request. For user profiles, Metadata API **60** provides the ability to add a user, authenticate a user and delete a user. The communication for data warehouse schema is to retrieve it.

Metadata API **60** allows a user to define new ways of looking at a business. A user cannot modify the public segments, the basic measures or the public measures. However, the user can create new Business Indicators and new Segments. In a typical organization of users and system administrators, only system administrators can create or change basic business measures. Administrators and knowledge workers can create, edit or delete public composite measures, public segments and public measure relationships.

The MetaData API **60** will handle the following requests from other client subsystems:

update metadata	from subsystems 55A/55B/55C
get report status	from Folder management subsystem 54
generate report	from Folder management subsystem 54
retrieve report	from Folder management subsystem 54
retrieve schema	from MDT Administrator Interface 57
update schedule	from Analyst Definition subsystem 56
cancel a report	from Analyst Definition subsystem 56
authenticate user	from Log-in module 50
add a user	from MDT Administrator Interface 57
delete a user	from MDT Administrator Interface 57
update user password	from MDT Administrator Interface 57

Metadata API **60** sends the following requests directly to DAI subsystem **14**:

disconnect from computer **32**

send data to DAI subsystem **14**

receive data from DAI subsystem **14**

Turning now to FIG. 3, DAI subsystem **14** includes return area manager **70**, InfoFrame generator **72**, metadata request module **74**, metadata repository **76**, and metadata load and update module **78**.

Metadata repository **76** contains a representation of metadata **25** within data warehouse **24**. This metadata **25** is the core of system **10**; it provides a customizable business view over the relational data in warehouse **24** and is the primary vocabulary for the specification of InfoFrames. Metadata repository **76** gets populated at startup time by DSM subsystem **16** from the persistent metadata representation in data warehouse **24**.

There are four fundamental kinds of metadata **25** in metadata repository **76**, listed and described below:

Business Concepts: business concepts represent the business dimensions along which the data can be viewed. Each dimension imposes a hierarchy over the underlying data, and dimensions can be combined to drive "drill-down" or "drill-up" operations. For example, a simple retail application might have two Business Concepts: Market and Product. The Market hierarchy is composed of Sales Regions, each of which consists of several States, each of which consists of a set of Stores. The Product Hierarchy is composed of a set of Departments (Home Electronics, Men's Clothing, Hardware), each Department is composed of product Categories (Shirts, Shoes, Slacks), and each Category is composed of individual manufacturer's product lines. Time is a dimension that is important in all applications, and will be represented in system **10**. Users can add new Business Concepts (see below). These, as all of the metadata **25** in metadata repository **76**, must be mapped into relational form (that is, into SQL) in order to actually query data warehouse **24**. Mapping is done by DSM subsystem **16** during the process of processing Dimensional Queries (see below).

Business Indicators: Business Indicators are the important measures of data of interest. For example, product Volume, Price, or Current Stock are all Business Indicators. The use of time in a query further refines the idea of a Business Indicator; for example, "Change in Volume" applies between two time periods.

Alerts: Alerts are essentially tests over the data, but they are not part of the metadata. They are specified in the Analyst in terms of the metadata. For example, a user might specify that if the available stock of a product falls by some percentage, to generate the appropriate InfoFrame. The user also specifies how often to check the Trigger condition. A list of Alerts is maintained by DAI subsystem **14** and executed by scheduler subsystem **18**. This metadata **25** is also available to DAI subsystem **14** and is used to generate InfoFrame information.

Measure Relationships: Measure Relationships are simple expressions of business causality; for example, "Increased Sales mean Increased Profit". This kind of metadata **25** is used to generate supporting information for a InfoFrame or, alternatively, alert the user to trends that run counter to the set of Measure Relationships.

Metadata **25** is initially created during installation of the present invention at the customer's site. The process of creating the metadata **25** is illustrated in more detail in FIGS. 7A–7E. What is included within metadata **25** depends on the

industry (some metadata 25 will be industry-specific and usable by all companies in that industry), the specific customer of the present invention, and the structure of the customer's data warehouse 24. During installation, some industry-specific metadata 25 is used, some company specific metadata 25 may be created, and the mapping information needed to map metadata 25 to data warehouse 24 is created. All metadata 25, including the mapping information, is stored in a set of relational tables. These relational tables are kept in data warehouse 24 and used by the present invention to create reports for the user.

Metadata request module 74 handles all requests for metadata 25, either from client subsystem 12 or DAI subsystem 14. Client subsystem 12 requests metadata 25 from DAI subsystem 14 to be presented to the end users. InfoFrame generator 72 requests metadata 25 in order to create Dimensional Queries as part of instantiating a InfoFrame for a user. A request for metadata 25 might be, for example, a request for all sub-concepts of a particular Business Concept.

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Metadata request module 74 also handles metadata updates from client subsystem 12. A user adds new Segments by specifying a new dimension from which to group the data. This dimension must be supported by an existing data attribute in the warehouse data. For example, a Product may include a List-Price and a Discount-Price. The user can specify a new dimension called "Discount-Factor", specified using the percent difference between the Discount-Price and the List-Price, and use that to create three new Segments: Heavily-Discounted Products, Slightly-Discounted Products, and Non-Discounted Products. These new Segments can now be used in subsequent InfoFrame requests, and, if indicated by the user, made persistent by writing them back into data warehouse 24 by metadata load and update module 78.

Request Structures are passed from one subsystem to another when one subsystem requires processing and results from another. Request Structures vary according to the type of request being sent. Most requests, however, have some common attributes, such as an identification field, an owner, a name and a description of the request.

Business Concept Update Requests are sent from client subsystem 12 to DAI subsystem 14 and are preferably issued only by the System Administrator. Business Concept Update Requests are requests for adding a new Business Concept to the metadata 25. The requests have the following format:

BC_ID:	ID which uniquely identifies this Business Concept
BC_NAME:	The name of this Business Concept
BC_DESC:	The description of this Business Concept
MAPPING:	Mapping of this Business Concept to data warehouse tables

Business Indicator Update Requests are sent from client subsystem 12 to DAI subsystem 14. Business Indicator Update Requests are requests for adding a new Business Indicator to the metadata 25.

Business Indicator Update Requests primarily include primitive and compound requests. Primitive requests have the following format:

BI_ID:	ID which uniquely identifies this Business Indicator
OWNER:	The user who created this Business Indicator
BI_NAME:	The name of this Business Indicator
BI_DESC:	The description of this Business Indicator

-continued

MAPPING:	Mapping of this Business Indicator to data warehouse tables
ROLLUP_OP:	Operator for performing the roll-up operation

Compound requests have the following format:

BI_ID:	ID which uniquely identifies this Business Indicator
BI_NAME:	The name of this Business Indicator
BI_DESC:	The description of this Business Indicator
EXP:	The expression which describes this Business Indicator function

Causal Indicator Update Requests are sent from client subsystem 12 to DAI subsystem 14. Causal Indicator Update Requests add a new Causal Indicator to the metadata 25. The request has the following format:

CI_ID:	ID which uniquely identifies this Casual Indicator
OWNER:	The user who created this Causal Indicator
CI_NAME:	The name of this Causal Indicator
CI_DESC:	The description of this Causal Indicator
BI_ID1:	Business Indicator which is the independent variable of this causal relationship
OP:	The operator for this causal relationship
BI_ID2:	Business Indicator which is the dependent variable of this causal relationship
RANGE:	When OP is +/−, the range where it is + and the range where it is −

Schema Requests are sent from client subsystem 12 to DAI subsystem 14 and may only be issued by the System Administrator. Schema Requests are requests to retrieve the data base schema from data warehouse 24. This type of request is just a simple unformatted message to DAI subsystem 14.

Segment Update Requests are sent from client subsystem 12 to DAI subsystem 14. Segment Update Requests are requests for adding a new Segment to the metadata 25. Segment Update Requests have the following format:

SEG_ID:	Id which uniquely identifies this Segment
OWNER:	The user who created this Segment
SEG_NAME:	The name of this Segment
SEG_DESC:	The description of this Segment
SEG_LEVEL:	Level in the Segment Hierarchy of this Segment
BC_ID:	The Business Concept for this Segment
ATTR_ID:	The Attribute(s) for this Segment
OP:	The operator(s) for this Segment
VALUE:	The value(s) for this Segment

InfoFrame Requests are sent from the Client subsystem to the DAI subsystem. This type of request is to create a new InfoFrame based on user specified selections. The request has the following format:

SR_ID:	ID which uniquely identifies this InfoFrame
OWNER:	The user who created this InfoFrame
SR_NAME:	The name of this InfoFrame
SR_DESC:	The description of this InfoFrame
SR-TYPE	One of the four types of InfoFrames
BC_ID:	The Business Concept for this InfoFames
SEG_ID:	The Segment(s) for this InfoFrame
TIME:	The time interval(s) for this InfoFrame

Dimensional Queries are sent from DAI subsystem 14 to DSM subsystem 16. Dimensional Queries formulate requests for data from data warehouse 24. DSM subsystem 16 converts Dimensional Queries into SQL statements.

The DAI subsystem 14 communicates a dimensional query to the DSM subsystem 16 as a list of metadata segment definitions or partition definitions, a list of metadata measure definitions and a Measure Value Table. The DSM subsystem 16 converts these to SQL Queries and submits them to the Data Warehouse 24. The results returned by the Data Warehouse to the DSM are returned to the DAI in the Measure Value Table.

Client subsystem 12 produces the following outputs to DAI subsystem 14:

Business Concept Update Requests
Business Indicator Update Requests
Causal Indicator Update Requests
Schema Requests
Segment Update Requests
InfoFrame Requests
Cancel Requests

DAI subsystem 14 provides the following outputs to client subsystem 12:

Business Concept Structures
Business Indicator Structures
Causal Indicator Structures
Schema Structures
Segment Structures
InfoFrames
Error/Status Codes

DAI subsystem 14 provides the following outputs to scheduler subsystem 18:

Schedule Analyst Request
Delete Analyst Request

DAI subsystem 14 provides the following outputs to DSM subsystem 16:

Dimensional Queries
Metadata Retrieval Requests
Schema Requests

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DSM subsystem 16 provides the following outputs to DAI subsystem 14:

Updated Metadata
Data from the Data Warehouse
Database Schema

DSM subsystem 16 provides the following outputs to data warehouse 24:

SQL Statements

DSM subsystem 16 receives the following inputs from data warehouse 24:

Metadata
Database Schema
Warehouse Data

Scheduler 18 provides the following output to DAI subsystem 14:

Analyst Definitions

Metadata load and update module 78 populates metadata repository 76 from the persistent metadata stored in data warehouse 24 upon system startup. In addition, when a user specifies new Business Concepts and indicates that he wants them saved, metadata load and update module 78 writes them back into data warehouse 24 for future use.

InfoFrame generator 72 fulfills the primary purpose of DAI subsystem 14. Report generation begins when a user's Analyst containing an InfoFrame definition is received by the DAI. The type of Analyst is used to select appropriate Drill Down Heuristics and Text Generation Rules from the set implemented in the DAI. Drill Down Heuristics are used to determine if there any data relationships between the segments of the free attributes of the target segment which must be reported. Text Generation Rules are used to determine what features of the target segment ought to be reported and what relationships to sibling segments, other segments in the restricted attributes of the target segment, ought to be reported. Text Generation rules may specify localizable text, graphs or tables as appropriate output. The output of the Report Generation process is a fully instantiated InfoFrame returned to client subsystem 12 in the form of HyperText Markup Language (HTML), a widely-used standard for building portable compound documents.

InfoFrame generator 72 has several kinds of knowledge:

Knowledge of how to map Abstract Queries into Dimensional Queries

Knowledge of how to use metadata 25 to generate default choices (choices not made by the user in the InfoFrame Request)

Knowledge of how to use both metadata 25 and data returned from the warehouse to guide the selection of both text components

Knowledge of how to use both metadata 25 and data returned from the warehouse to guide the selection of different types of graphical presentations.

For example, the Summary InfoFrame may take as arguments a Business Concept, a Business Indicator, and a time period. The Report Generation Module uses the user selected parameters, for example, the Business Concept "Product", the Business Concept Segment "Men's Shirts", the Business Indicator "Volume", and the time period "December 1994" to create a Dimensional Query. This Dimensional Query is sent to the Data and Schema Manipulation subsystem, which translates this query into SQL and actually executes it. It returns the computed data to DAI subsystem 14, where other Abstract Queries might embed the actual number in a bullet.

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Other Abstract Queries have conditionals associated with them. To build off the previous example, another part of the summary System Template might specify the creation of a graph, showing how the target-business-indicator (volume) is apportioned among the segments of the target-business-concept (shirts). In this case, report generator 72 makes a metadata request to return the set of segments, in this example, the dimension that specifies the shirt manufacturer. All volume information is requested for each manufacturer of shirts. Now, additional information guides report generator 72 in the selection of a choice of graph. For example, if the number of segments (manufacturers in this case). is small, like 7 or less, then a pie graph is appropriate, otherwise, a bar graph is preferred. If the number of segments is very large, then aggregate the bottom 20 percent (in terms of the Business Indicator, in this case, Volume) and use that aggregate with the label "Other" in the graph.

Return area manager 70 keeps track of InfoFrames and Alert Evaluations with positive results by user that are waiting for delivery to client subsystem 12. When a user logs into system 10, client subsystem 12 issues a request to DAI subsystem 14 to return all data for that user in the return area. Return area manager 70 retrieves the information from the return area on server computer 32 and sends it back to client computer 30 through DAI subsystem 14.

Turning now to FIG. 4, DSM subsystem 16 includes SQL generator 80 and metadata query module 82.

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SQL generator 80 translates dimensional queries received from DAI subsystem 14 into SQL statements used to retrieve data from data warehouse 24. A mapping from business

concepts to database entities is stored in the metadata 25 and is used in the formatting of the SQL statements. SQL generator 80 provides to DAI subsystem 14 for use in creating InfoFrames.

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Metadata query generator 82 processes requests for metadata 25 submitted by DAI subsystem 14. At system startup, DAI subsystem 14 requests all metadata 25 in order to initialize the knowledge base. Metadata query generator 82 is also invoked whenever the user modifies his Segments, causing DAI subsystem 14 to issue an update metadata request.

Turning now to FIG. 5, scheduler subsystem 18 includes alert and report scheduler 90. The scheduler periodically tests queued Scheduled Analysts and will dispatch those to the have come due to the DAI subsystem 14. It will periodically dispatch all submitted Exception Analysts to the DAI subsystem 14 so that they can test for trigger conditions. The schedule and trigger periods are independently configurable by the MDT Administrator. The scheduler passes analysts to the CDAI 14B, by way of the Dispatcher 2513 (FIG. 27).

Turning now to FIGS. 6–12, client subsystem 12 and its operation are illustrated in more detail.

Client subsystem 12 includes a primary overlay 98 which appears when client subsystem 12 is executed. Overlay 98 includes three display areas 100–104 within a common Folders window, pull-down menus 106, and buttons 110–120. The Folders window may be maximized (as it is shown in FIG. 6) to eliminate its borders, resized, or minimized as an icon within client subsystem 12. The Folders window cannot be closed.

Display area 100 contains a list of folders, which represent the metaphor used by client subsystem 12 in organizing InfoFrames and the analysis that creates them. A folder is opened by highlighting it and selecting it with input device 21. The first folder in the list is opened by default when client subsystem 12 is executed.

Display area 102 contains a list of InfoFrames within a selected folder. A InfoFrame may be viewed by highlighting it and selecting it with input device 21. An Analysis window 136 appears containing the InfoFrame. The title bar of the window indicates the type of preselected analysis that has been performed. For example, in FIG. 12, "change" analysis was preselected by a user to be the type of analysis to run. The Analysis window 136 may be maximized (as it is shown in FIG. 12) to eliminate its borders, resized, or minimized as an icon within client subsystem 12. The Analysis window 136 may be closed by selecting button 122 (FIG. 12) or by a manner well known to users of Windows 3.1, Windows 95, and other windows operating environments.

Display area 104 contains a list of Analysts within a selected folder. An Analyst is a personification of preselected operations performed on preselected data for the purpose of generating a InfoFrame. An Analyst may be viewed by highlighting it and selecting it with input device 21. Analyst Builder windows 130 (FIGS. 7A–7E) appears containing the preselected settings saved within the Analyst and used to generate the corresponding InfoFrame listed in display area 102. (The InfoFrames listed in display area 102 are arranged in the same order as the Analysts listed in display area 104, and have the same titles as the corresponding Analysts). The Analyst Builder window 130 may be not be maximized, resized, or minimized as an icon; it may only be closed in a manner well known to users of Windows 3.1, Windows 95, and other windows operating environments.

Buttons 110–122 (FIG. 6) implement the primary operational commands within pull-down menus 106 and are activated using a pointing device. Button 110 calls the Analyst Builder windows 130 (FIGS. 7A–7E).

Button 112 calls a Segments divider within a Business Information Setup window 132 (FIG. 8A). Button 116 deletes a selected file or folder within display areas 100–104. Button 118 creates a new folder. Button 120 calls the Analysis window 136 with a selected InfoFrame from display area 102. Button 122 closes client subsystem 12. Button 150 is a print button, button 151 allows the user to create measures, and button 152 allows the user to create or edit measure relationships.

With reference to FIGS. 7A–7E, Analyst Builder window 130 allows a user to define how selected data is analyzed. An Analyst is named under the Analyst Name field. A type of analysis is chosen under the Type of Analysis field. A primary measure to be used in implementing the analysis is chosen under the Primary Measure field. Segments to be reported on are chosen from the list of Defined Segments. Finally, a period for the InfoFrame is defined under the Time Slice Considered fields. A InfoFrame can be created immediately by selecting the Report Now button, or can be scheduled as part of a batch of InfoFrames by selecting the Schedule Analyst button.

With reference to FIG. 8A, the Segments divider within the Business Information Setup window 132 allows Segments to be created, modified, or deleted. A description of the segment appears in the Description field. Upon activation of button 801 by the user, the window 132 of FIG. 8B is launched, allowing the user to edit segment definitons.

With reference to FIG. 9A, Measures of information may be created and modified within the Measures divider of the Business Information Setup window 132. A name for each Measure appears in the Measure Name field. A definition of a Measure appears in the Definition field. Mathematical operators, Time Slice constraints, Segment constraints, and constraints from other Measures may be inserted into the Definition using the corresponding buttons below the Definition field. With respect to FIGS. 9B and 9C, windows 132 may be displayed to select measures and select segments, respectively. (217)

With reference to FIG. 10, Measure relationships may be defined and modified within the Measure Relations divider of the Business Information Setup window 132. Measure relationships are defined in terms of an if-then statement. A primary measure and whether it increases or decreases is selected in the Measure field, which represents the "If" part of the If-Then statement. Measures within the Unrelated field may be moved to either the Decreases field or the Increases field to form the "Then" part of the If-Then statement. With respect to FIG. 11, measure relationships may be restricted by means of the window 132 of that figure.

A batch of InfoFrames may be individually scheduled for automatic production. Scheduling of InfoFrames is particularly useful to those users that require periodic InfoFrames. InfoFrame time intervals may be selected under the Time Interval field, which provides daily, weekly, and monthly reporting options.

With reference to FIG. 12, a sample InfoFrame is shown within Analysis window 136. The type of analysis performed is indicated in the InfoFrame and in the title bar as "Change Analysis". The Segment (previously defined within the Segments divider of the Business Information Setup window 132) is "Store Ages Greater than 3 Years". The Measure (previously define within the Measures divider of the Business Information Setup window 132) is "Same Store Sales". The Time Slice (previously defined in the Time Slice Considered fields of the Analyst Builder window 130) is "Year to date 1995 vs. Last Year".

The InfoFrame provides a concise statement of changes that have occurred in the Primary Measure, Same Store Sales, and changes that have occurred in Measures related to the Same Store Sales, Stores Remodeled, and previously defined within the Measure Relations divider of the Business Information Setup window **132**. The InfoFrame then contains an explanation, including a graph, for the change in the Primary Measure, Same Store Sales.

InfoFrame may include multiple instances of HTML associated with a Measure, representing hyperlinks to text data or graphic data representing the results of the Measure.

Turning now to FIG. **13**, a method for creating metadata **25** using client subsystem **12** is illustrated beginning with START **140**.

In step **141**, the user specifies a Business Concept.

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In step **142**, the user specifies one or more attributes for the Business Concept.

In step **144**, client subsystem **12** provides the user with the list of columns of tables in data warehouse **24**.

In step **146**, the user maps every attribute to a column. The user can provide a textual description of the business concepts and the attributes.

In step **148**, the user specifies one or more Business indicators by "mapping" a Business Indicator to a column in a table within data warehouse **24**.

In step **150**, client subsystem **12** provides the user with a list of columns for the purpose of mapping Business Indicators as well.

In step **152**, user selects an "aggregate method" for the Business Indicator that is mapped, which specifies how values for the Business Indicator are aggregated. The system supports the following aggregate methods:

Add
Average
Min
Max
Count
Last in period
First in period

In step **154**, the user selects the unit of measurement, and specifies whether the Business Indicator is a currency. The user can optionally specify a plural form of the Business Indicator, a verb to describe change in the value of the Business Indicator, the precision for reporting the Business Indicator and a textual description of the Business Indicator.

In step **156**, client subsystem **12** ensures that tables having Business Indicator columns can be joined with tables that have Business Attribute columns.

In step **158**, client subsystem **12** determines whether the user wishes to enter additional Business Concepts. If so, the method returns to step **142**. If not, the method ends at step **160**.

The preceding description forms an overview of the present invention. The following sections describe the invention in further detail, broken into further sections.

2. Client Subsystem **12**

The client subsystem **12** is described in further detail below.

FIG. 14 illustrates a more detailed block diagram of the client subsystem **12**. Client subsystem **12** contains three subsystems: User Interface (UI) **1401**, Manager **1402**, and Server APIs **1403**. As its name implies, the user interface subsystem **1401** allows the user **1405** to interact with the client **12**. At this level of detail, it can be seen that the User Interface subsystem **1401** uses services of both the Manager **1402** and the Server APIs **1403**; the Manager **1402** also uses services from the Server APIs **1403**. The Server APIs subsystem **1403** provides high level APIs which abstract all client **12** interactions with the DAI subsystem **14**. All communications between the client **12** and the DAI subsystem **14** are sent through the Client Server Module (CSM) **1404**, which is described in further detail below.

FIG. **15** illustrates a block diagram of the client subsystem **12** having an increased level of detail over the block diagram of FIG. **14**. The user interface subsystem **1401** contains all portions of the program that are visible to the user **1405**. Because this subsystem may be implemented as a standard MS-Windows style program, most of the units within the interface are either windows or dialog boxes. Each window or dialog box in the interface has one main class which defines its behavior, as detailed below. Some window or dialog classes also use other utility classes, which will also be defined below, where appropriate.

The "top level" of control within the client subsystem **12** is the Application object **1511**. The application object **1511** is constructed automatically by the Microsoft Foundation Class (MFC) library's start-up code. The application object has two primary responsibilities: performing login validation, and displaying the main frame window. The frame window in a Multiple Document Interface (MDI) application owns the Menus, Toolbar, and Statusbar, and creates child window objects.

The User Login process consists of two steps: getting a User Name and Password from the User, and sending them to the Connect function of the Server APIs subsystem **1403**. There are four possible results from an attempted Connect to the server **32**:

login succeeded
login failed
too many login failures
no response from server **32**; network down

Upon an unsuccessful login, the login dialog is re-displayed, and the user **1405** may re-enter his/her name and/or password. After a certain number of unsuccessful attempts (number determined by server **32**, not client **12**), the server **32** will return the "too many failures" result, and the client **12** program will inform the user **1405** of this result, and then exit. If the network or server are down, the client **12** will start up in "off-line" mode, which allows the user **1405** to view saved InfoFrames, but not to create or edit Analysts, or send InfoFrame generation requests.

Upon a successful connect, the application will display the main frame window. A successful Connect result additionally returns an indication of whether the user **1405** has Administrator (MDTA) privileges; if so, the frame window is informed, so that special menu items may be enabled.

The Application object **1511** may make the following requests of other subsystems:

Function Used	Subsystem
Connect	Session Management API [Server APIs subsystem 1403]
Disconnect	Session Management API [Server APIs subsystem 1403]
Display ManagerWindow	Manager Window [UI subsystem 1401]

The Application object **1511** is an instance of the clnt_App class. It creates one instance each of clnt_UserLoginDlg and clnt_MainFrame.

Class clnt_App is a subclass of the MFC class CWinApp. We inherit most of the standard behavior of the CWinApp, but override the InitInstance function, in which we run the

User Login process, and if successful, construct our main window, an instance of clnt_MainFrame.

clnt_MainFrame is a subclass of MFC class CMDIFrameWnd. We override the OnCreate function, in order to initialize the Toolbar, and Menus, and to create the initial Manager Window instance **1512**.

The clnt_MainFrame instance handles some of the Menu and Toolbar requests, while others are handled by whichever Child Window is active (one of the four Manager Windows **1512** or the InfoFrame Viewer window **1517**, as described below). The clnt_MainFrame instance is also responsible for enabling/disabling menu items that vary depending on which Child Window is active.

The User Login dialog is controlled by an instance of the clnt_UserLoginDlg class, a subclass of the MFC class CDialog. The clnt_UserLoginDlg instance displays a dialog which asks the User to enter a name and password. The name and password strings are returned to the calling function when the User clicks the "OK" button.

The Toolbar is controlled by an instance of class clnt_Toolbar, a subclass of MFC's CToolBar. Class clnt_Toolbar inherits all functionality from CToolBar, and adds support for drag-and-drop. Instances of clnt_Toolbar accept drops of one Folder (onto Trash button), one or more Analysts (onto Trash, RunNow, or View buttons), and one or more InfoFrames (onto Trash, View, and Print buttons).

The Business Information Definition **1515** includes all functionality related to addition, modification or deletion of Segments, Measures, and Measure Relationships.

Three dialog boxes are used in the Business Information Definition **1515** process; one for each type of Business Information to be edited. The dialogs are controlled by instances of the following classes which are instantiated by clnt_MainFrame (in response to User requests through the Menu or Toolbar).

clnt_BuildMeasureDlg

This dialog allows the user to update or delete an exisiting measure, or create a new Measure.

clnt_BuildSegmentDlg

This dialog allows the user to update or delete an exisiting segment, or create a new segment by defining attribute restrictions.

Clnt_BuildRelationDlg

This dialog allows the user to update or delete an exisiting MeasureRelation, or define a new relationship.

The Measure Relationship dialog uses the following services from other subsystems:

Function Used	SubSystem
GetMeasureRelationship	Metadata API [Server APIs subsystem 1403]
AddMeasureRelationship	Metadata API [Server APIs subsystem 1403]
DeleteMeasureRelationship	Metadata API [Server APIs subsystem 1403]
UpdateMeasureRelationship	Metadata API [Server APIs subsystem 1403]

The Measure dialog uses the following services:

Function Used	SubSystem
AddMeasure	Metadata API [Server APIs subsystem 1403]
DeleteMeasure	Metadata API [Server APIs subsystem 1403]

-continued

Function Used	SubSystem
UpdateMeasure	Metadata API [Server APIs subsystem 1403]
GetAllAnalysts	Metadata API [Server APIs subsystem 1402]

The Segment dialog uses the following services:

Function Used	SubSystem
AddSegment	Metadata API [Server APIs subsystem 1403]
UpdateSegment	Metadata API [Server APIs subsystem 1403]
DeleteSegment	Metadata API [Server APIs subsystem 1403]
GetAllAnalysts	Metadata API [Server APIs subsystem 1402]

The Business Information Setup section **1515** is controlled by instances of the following classes: clnt_BuildRelationshipDlg, clnt_BuildMeasureDlg, clnt_BuildSegmentDlg and clnt_BuildRestrictDlg (all subclasses of the MFC's CDialog). If the user **1405** selects to modify a private segment or measure, the clnt_MeasureDefDlg and clnt_SegmentDefDlg objects will be responsible for traversing through the list of existing Analysts and InfoFrames and if the segment or measure is found, the objects will take the following actions:

In case of Delete

A message will be displayed to the User **1405** that deleting will cause some Analysts to no longer run correctly. The User **1405** will be presented with a list of Analysts that will be affected by this deletion. When an Analyst runs on a deleted segment or measure an error message will be returned.

In case of Modify

The newest segment/measure definition will always be used. The old definitions will be replaced.

The User change requests will be transferred to DAI (through the Server APIs subsystem) for immediate update of the Metadata.

The Analyst Builder dialog box **1513** allows the User **1405** to select the parameters needed to generate a specific InfoFrame (see below). It also allows the User **1405** the option of Scheduling and/or defining Trigger conditions for an Analyst. To allow this to happen, the main Analyst dialog will prompt the User **1405** to complete a sequence of sub-dialogs: Measures, Segments, TimeSlice, Schedule, and Trigger.

Other portions of the User Interface subsystem **1401** (i.e., Menus, Toolbar, or a Manager Window) invoke the Analyst Builder dialog **1513** either by passing it an existing Analyst object to view/edit, or by passing a NULL parameter, indicating that a new Analyst is to be created.

The clnt_AnalystSheet dialog will instantiate a clnt_InfoFrameRequest object when the User **1405** requests to "Save" on a new Analyst or "Save As" on an existing Analyst.

The clnt_AnalystSheet dialog makes the following requests to other subsystems:

Function Used	SubSystem
NewAnalyst	Manager API [Manager subsystem 1402]
UpdateAnalyst	Manager API [Manager subsystem 1402]
RunAnalystNow	InfoFrame Generation API [Server APIs subsystem 1403]
SetFrameDefinition	InfoFrameRequest API [Manager subsystem 1402]
GetFrameDefinition	InfoFrameRequest API [Manager subsystem 1402]

The clnt_AnalystSheet class instantiates sub-dialogs of the following classes: clnt_AnalystMeasurePage, clnt_AnalystSegmentPage, clnt_AnalystTimeSlicePage, clnt_AnalystSchedulePage, clnt_AnalystTriggerPage (all subclasses of MFC's CPropertyPage). These correspond to five panels within the main dialog box which the User **1405** will be led through in sequence.

Also, the Analyst subsystem **1513** will use clnt_MetaTree class and clnt_MeausreMap class which will provide access to the Metadate tables through MetaData API's.

The clnt_AnalystSheet subdialogs will be dynamically populated with the proper controls according to the User's **1405** selection of the Analyst type. The User input from the Dialog interfaces will be saved in a clnt_infoFrameRequest object and returned to Manager subsystem to be saved (and submitted for scheduling, if a Schedule is present—see below regarding further details of the scheduler subsystem **18**).

The clnt_AnalystMeasurePage makes the following requests to the other subsystems:

Function Used	SubSystem
GetName	InfoFrameDefinition API [Manager subsystem 1402]
SetName	InfoFrameDefinition API [Manager subsystem 1402]
GetFrameType	InfoFrameDefinition API [Manager subsystem 1402]
SetFrameType	InfoFrameDefinition API [Manager subsystem 1402]
GetTargetMeasure	InfoFrameDefinition API [Manager subsystem 1402]
SetTargtMeasure	InfoFrameDefinition API [Manager subsystem 1402]
GetComparisonMeasure	InfoFrameDefinition API [Manager subsystem 1402]
SetComparisonMeasure	InfoFrameDefinition API [Manager subsystem 1402]
GetAdditionalMList	InfoFrameDefinition API [Manager subsystem 1402]
SetAdditionalMList	InfoFrameDefinition API [Manager subsystem 1402]

The clnt_AnalystSegmentPage makes the following requests to other subsystems:

Function Used	SubSystem
GetTargetSegment	InfoFrameDefinition API [Manager subsystem 1402]
SetTargetSegment	InfoFrameDefinition API [Manager subsystem 1402]
GetComparisonSegment	InfoFrameDefinition API [Manager subsystem 1402]
SetComparisonSegment	InfoFrameDefinition API [Manager subsystem 1402]
GetAdditionalSList	InfoFrameDefinition API [Manager subsystem 1402]

-continued

Function Used	SubSystem
SetAdditionalSList	InfoFrameDefinition API [Manager subsystem 1402]
GetPartitionList	InfoFrameDefinition API [Manager subsystem 1402]
SetPartitionList	InfoFrameDefinition API [Manager subsystem 1402]
GetParentPartition	InfoFrameDefinition API [Manager subsystem 1402]
GetParentPartition	InfoFrameDefinition API [Manager subsystem 1402]

The clnt_AnalystTimeSlicePage makes the following requests to other subsystems:

Funciton used	Subsystem
GetPeriodType	InfoFrameTimeSlice API [Manager subsystem 1402]
SetPeriodType	InfoFrameTimeSlice API [Manager subsystem 1402]
GetAnalysisType	InfoFrameTimeSlice API [Manager subsystem 1402]
SetAnalysisType	InfoFrameTimeSlice API [Manager subsystem 1402]
GetYearType	InfoFrameTimeSlice API [Manager subsystem 1402]
SetYearType	InfoFrameTimeSlice API [Manager subsystem 1402]
GetTrendInterval	InfoFrameTimeSlice API [Manager subsystem 1402]
SetTrendInterval	InfoFrameTimeSlice API [Manager subsystem 1402]
GetDuration	InfoFrameTimeSlice API [Manager subsystem 1402]
SetDuration	InfoFrameTimeSlice API [Manager subsystem 1402]
GetNumDuration	InfoFrameTimeSlice API [Manager subsystem 1402]
SetNumDuration	InfoFrameTimeSlice API [Manager subsystem 1402]
GetBasePeriod	InfoFrameTimeSlice API [Manager subsystem 1402]
SetBasePeriod	InfoFrameTimeSlice API [Manager subsystem 1402]
GetBaseThruPeriod	InfoFrameTimeSlice API [Manager subsystem 1402]
SetBaseThruPeriod	InfoFrameTimeSlice API [Manager subsystem 1402]
GetCompPeriod	InfoFrameTimeSlice API [Manager subsystem 1402]
SetCompPeriod	InfoFrameTimeSlice API [Manager subsystem 1402]
Operator=	InfoFrameTimeSlice API [Manager subsystem 1402]
GetTimeSlice	InfoFrameTimeSlice API [Manager subsystem 1402]

The clnt_AnalystSchedulePage makes the following requests from other subsystems:

Funciton	Subsystem
GetNumInterval	InfoFrameSchedule API [Manager subsystem 1402]
SetNumInterval	InfoFrameSchedule API [Manager subsystem 1402]
GetInterval	InfoFrameSchedule API [Manager subsystem 1402].
SetInterval	InfoFrameSchedule API [Manager subsystem 1402]
GetStartDate	InfoFrameSchedule API [Manager subsystem 1402]

-continued

Funciton	Subsystem
SetStartDate	InfoFrameSchedule API [Manager subsystem 1402]
GetNumLimit	InfoFrameSchedule API [Manager subsystem 1402]
SetNumLimit	InfoFrameSchedule API [Manager subsystem 1402]
GetLimit	InfoFrameSchedule API [Manager subsystem 1402]
SetLimit	InfoFrameSchedule API [Manager subsystem 1402]
GetScheduleFlag	InfoFrameSchedule API [Manager subsystem 1402]
SetScheduleFlag	InfoFrameSchedule API [Manager subsystem 1402]
GetTriggerFlag	InfoFrameSchedule API [Manager subsystem 1402]
SetTriggerFlag	InfoFrameSchedule API [Manager subsystem 1402]
Operator=	InfoFrameSchedule API [Manager subsystem 1402]
SetSchedule	InfoFrameReuest API [Manager subsystem 1402]

The clnt_AnalystTriggerPage makes the following requests from other subsystems:

Function	Subsystem
GetTriggerList	InfoFrameTrigger API [Manager subsystem 1402]
SetTriggerList	InfoFrameTrigger API [Manager subsystem 1402]
GetMessageFlag	InfoFrameTrigger API [Manager subsystem 1402]
SetMessageFlag	InfoFrameTrigger API [Manager subsystem 1402]
GetFrameFlag	InfoFrameTrigger API [Manager subsystem 1402]
SetFrameFlag	Update the state of the frame generation action
GetAnalystList	InfoFrameTrigger API [Manager subsystem 1402]
SetAnlystList	InfoFrameTrigger API [Manager subsystem 1402]
Operator=	InfoFrameTrigger API [Manager subsystem 1402]
GetMeasure	Trigger API [Manager subsystem 1402]
SetMeasure	Trigger API [Manager subsystem 1402]
GetOperator	Trigger API [Manager subsystem 1402]
SetOperator	Trigger API [Manager subsystem 1402]
GetOperand1	Trigger API [Manager subsystem 1402]
GetOperand2	Trigger API [Manager subsystem 1402]
SetOperand1	Trigger API [Manager subsystem 1402]
GetOperand2	Trigger API [Manager subsystem 1402]
GetValue1	Trigger API [Manager subsystem 1402]
GetValue2	Trigger API [Manager subsystem 1402]
SetValue1	Trigger API [Manager subsystem 1402]
SetValue2	Trigger API [Manager subsystem 1402]
Operator=	Trigger API [Manager subsystem 1402]
SetTrigger	InfoFrameRequest API [Manager subsystem 1402]

The following is a list of user input requirements for each InfoFrame Type:

(R=Required, O=Optional)

clnt_MeasureDlg

Analysis Type	Target Measure	Additional Measures	Comparison Measure
Change	R	O	
Segment Comparison	R	O	
Measure Comparison	R		R
Summarization	R	O	
Trend	R	O	

clnt_SegmentDlg

Analysis Type	Target Segment	Additional Measures	Comparison Measure
Change	R	O	
Segment Comparison	R	O	R
Measure Comparison	R	O	
Summarization	R	O	
Trend	R	O	

clnt_TimeSliceDlg

Analysis Type	Base Period	Comparison Period	Time Interval
Change	R	R	
Segment Comparison	R		
Measure Comparison	R		
Summarization	R		
Trend	R		R

The InfoFrame Viewer Window **1517** displays an InfoFrame on screen (see below). In addition to displaying the InfoFrame data, the Viewer **1517** supports the "Drill Down" capability by presenting hot spots to the User **1405**, and generating the appropriate requests when a hot spot is selected. The InfoFrame Viewer also gives the User a capability to Annotate an InfoFrame.

When InfoFrame Viewer **1517** is created, it receives the name of the InfoFrame file and a pointer to the InfoFrame object. This data is parsed (further processing is also done, including generating graphs from embedded data), then displayed.

The Parser capability within the InfoFrame Viewer module **1517** is also used for the SaveAs requests; the raw InfoFrame data is translated to standard HTML data (i.e., MDT-specific graph data is translated into a graphical image in a standard format), and is written to a file in either ASCII or Unicode characters. The InfoFrame Viewer Window **1517** also supports the InfoFrame Print function. This functionality is built on the capabilities provided by the CDocument and CScrollView classes of MFC.

The InfoFrame Viewer subsystem **1517** makes the following requests to other subsystems.

Function Used	SubSystem
UpdateInfoFrame	Manager API [Manager Subsystem 1402]
DrillDown	Manager API [Manager Subsystem 1402]

Parser: the clnt_Parser class provides the HTML parsing capability for the Client **12** through the following three functions:

Service Provided	Description
doParse	Called by the InfoFrame Viewer, this function parses the given HTML data, and returns a list of clnt_Tag objects, each representing an element of the HTML Data. The clnt_Tag objects can contain lists of sub-Tags, so that nesting is preserved.

-continued

Service Provided	Description
SaveAsHTML_Unicode	Called by the Manager 1402 when the User 1405 requests to Save an HTML file. Parses the HTML data to replace any non-standard HTML elements with standard HTML data (for example, raw graph data must be transformed into a graphic image). Writes transformed data into a file, using Unicode characters.
SaveAsHTML_ASCII	Same as above, except characters are written out as ASCII.

Viewer: the Viewer is implemented using the MFC Document/View architecture. Class clnt_Viewer is a subclass of CScrollView (MFC), which provides the automatic scrolling. Class clnt_ParserDoc is a subclass of CDocument. On creation, it instantiates a clnt_Parser object to parse the HTML Data. The clnt_Viewer then traverses the returned list of clnt_Tag objects and places their visual representations in the Window.

The following collection of controls are used by the user interface subsystem **1401**:

clnt_TreeCtrl

All dialog controls which will be representing segments and/or partitions inherit from this class rather than from the MFC's CTreeCtrl. clnt_MetaTree control also inherits from this class.

clnt_MetaTree

This control is used to represent the Metadata segments and partitions in a hirerchical format. The following dialogs subclass this control: clnt_AnalystSegmentPage, clnt_BuildSegmentDlg, clnt_RestrictMeasureDlg.

clnt_TopLevelSegmentCombo

This conttrol is used to represent all Metadata top level segments in a DropDown ComboBox. The following dialogs subclass this control: clnt_AnalystSegmentPage, clnt_BuildSegmentDlg, clnt_RestrictMeasureDlg.

clnt_DurationCombo

This control represents the user's conditional operator choices in a dropdown combobox format. The following dialogs subclass this control: clnt_AnalystPeriodPage, clnt_AnalystSchedulePage.

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clnt_OperatorCombo

This control represents the user's conditional operator choices in a dropdown combobox format. The following dialogs subclass this control: clnt_AnalystPeriodPage, clnt_AnalystSchedulePage.

clnt_DateEdit

This control is used to represent the locale date. It validates the user entry and formats the date properly for the locale. The following dialogs subclass this control: clnt_AnalystPeriodPage, clnt_AnalystSchedulePage.

lnt_ReadOnlyListBox

This control is used for a non-select listbox. There is no dependencies from other subsystems. The following dialog subclasses this control: clnt_BuildSegmentDlg

The clnt_MetaTree control uses the following services from other subsystems:

Function Used	SubSystem
GetSegment	Metadata API [Server APIs subsystem 1403]
GetPartition	Metadata API [Server APIs subsystem 1403]

The clnt_TopLevelSegmentCombo uses the following services from other subsystems:

Function Used	SubSystem
GetSegment	Metadata API [Server APIs subsystem 1403]

The clnt_MeasureCombo uses the following services from other subsystems:

Function Used	SubSystem
GetBasicMeasure	Metadata API [Server APIs subsystem 1403]
GetCompositeMeasure	Metadata API [Server APIs subsystem 1403]

The Administrator Interface **1516** consists of two tasks: User Account setup, and Metadata Builder. The User Accounts setup dialog allows the MDTA (Administrator) to create and manager User accounts, including login name, password, and User type. The Metadata Builder allows the MDTA to define Dimensions, Attributes, and Basic Measures, to create Segments, map columns for Time values, and define Year types.

The User Accounts screen utilizes the clnt_UserLogin class from the Server APIs subsystem **1403**. The Metadata Builder screens utilize nearly all metadata functions provided by the Server APIs subsystem **1403**. This includes the services of classes clnt_Communications, clnt_Dimension, clnt_Attribute, clnt_BasicMeasure, and clnt_Segment. It also uses the clnt_Schema class for access to the Data Warehouse schema.

The User Accounts dialog is controlled by an instance of clnt_UserAccountsDlg, a subclass of MFC's CDialog. The interface that clnt_UserAccountsDlg presents to the rest of the system is the standard for CDialog objects; the instance is constructed, and then DoModal( ) is called to display the dialog. The call to DoModal( ) returns only when the User **1405** presses the "Cancel" or "Close" button.

The Metadata Builder dialog may be a "wizard" style dialog, meaning that it presents a series of sub-dialogs in a pre-determined order. The User **1405** may press the "Next" and "Back" buttons to traverse the list of sub-dialogs, and may press "Cancel" to exit from the Metadata Builder. The "frame" of the wizard is implemented by class clnt_MasterSetup, which is a subclass of MFC's CPropertySheet. The constructor of clnt_MasterSetup creates one instance each of the dialog "pages" (clnt_AttributeDefinition, clnt_AttributeMapping, clnt_AttributeValueDefinition, clnt_AutomaticSegments, clnt_BasicMeasureDefinition, clnt_BasicMeasureMap, clnt_DimensionDefinition, clnt_Joins, clnt_TimeDimension, clnt_YearDefinition). The pages are loaded into the "wizard" automatically when it is displayed. This is transparent to the rest of the Client application **12**, which simply constructs the Metadata Builder and calls DoModal( ) on the instance.

Each of the "pages" loads its initial display data through calls to the ServerAPIs **1403** metadata classes, and each page responds to the "Save" button by updating its data through the ServerAPIs **1403**.

The clnt_MasterSetup has one linked list for each type of metadata used. Each list contains zero or more clnt_SetupObject objects. The clnt_SetupObject object contains two data members: one pointer to a CObject and one clnt_ObjectState enumeration. clnt_ObjectState can take on one of four values: STATE_EXISTING, STATE_NEW, STATE_DELETED, STATE_MODIFIED. These linked

lists are available to every "wizard" page. Every time the user 1405 adds, deletes or modifies a metadata object, it is added to the appropriate linked list. These linked lists are used to determine which objects to display to the user 1405 and which ones to hide from the user 1405. The linked lists are also used by the "CANCEL" and "SAVE" buttons. When the user 1405 presses the "CANCEL" button, all objects in the linked lists are deleted. When the user 1405 presses the "SAVE" button, all objects in the linked lists are accessed. If the value of the enumeration is STATE_EXISTING the object is deleted from the list. If the value is STATE_NEW the object is added to the metadata on the server and deleted from the list. If the value is STATE_DELETED the object is deleted from the metadata on the server and the object is deleted from the list. If the value is STAT_MODIFIED the object is updated in the metadata on the server and the object is deleted from the list.

The "SAVE" button on the "wizard" page adds, deletes and modifies objects in a certain order. For deleting objects, the following table lists the object to be deleted in the left column and the associated objects in the right column that will be deleted from the linked lists on the Client 12 if they exist. The row order in the left column defines which object will be deleted, added or modified first. Dimensions would be added first and Year Definitions would be added last.

Object	Associated objects
Dimension	Attribute, Segment
Attribute	Enumerate Attribute Value, Restricted Integer Attribute, Restricted Float Attribute, Segment, Attribute Measure Join, Attribute Attribute Join
Enumerated Attribute Value	<none>
Restricted Integer Attribute	<none>
Restricted Float Attribute	<none>
Segment	Numerical Attribute Restriction
Numerical Attribute Restriction	<none>
Enumerate String Attribute Restriction	<none>
Partition	<none>
Basic Measure	Attribute Measure Join
Composite Measure	Constant, Segment List, Attribute Measure Join
Constant	<none>
Segment List	<none>
Attribute Measure Join	<none>
Attribute Attribute Join	<none>
Measure Relationship	Measure Relation Range Restriction, Measure Relation Magnitude Restriction, Measure Relation Segment Constraint
Measure Relation Range Restriction	<none>
Measure Relation Magnitude	<none>
Measure Relation Segment Constraint	<none>
Time Definition	<none>
Time Mapping	<none>
Year Definition	<none>

When the user deletes an object that already exist in the metadata 25 on the server 34, just that object is deleted. The "associated objects" for that object will be deleted by the DAI subsystem 14.

The Manager Windows 1512 give the User 1405 access to all types of data which are stored by the Manager subsystem 1402: Folders, Analysts, and InfoFrames, as well as information about Pending InfoFrames.

There are four types of Manager Windows 1512, each offering a different view of this data:

Analyst list (flat list of all Analysts)

InfoFrame list (flat list of all InfoFrames)

Folder View (includes Folder hierarchy; shows InfoFrames & Analysts in current Folder)

Pending Queue (flat list of InfoFrames pending in the DAI 14).

Note that the Pending Queue window is included with the other three Manager Windows because of its similarity in construction and interface behavior; the data it displays is actually quite distinct from that of the other three Windows.

Drag-and-Drop features are also supported by the Manager Windows 1512. The Analyst list, InfoFrame list, and Folder View can be the source of a "drag" operation (Users may drag one Folder, one or more Analysts, or one or more InfoFrames). The Folder View may also be the destination of a "drag" operation.

The first three Manager Window types (Analyst list, InfoFrame list, Folder view) use the following services from other subsystems:

Function Used	SubSystem
GetRootFolder	Manager API [Manager subsystem 1402]
GetTrashBin	Manager API [Manager subsystem 1402]
GetAllAnalysts	Manager API [Manager subsystem 1402]
GetAllInfoFrames	Manager API [Manager subsystem 1402]
NewFolder	Manager API [Manager subsystem 1402]
RemoveFolder	Manager API [Manager subsystem 1402]
MoveFolder	Manager API [Manager subsystem 1402]
SetFolderName	Manager API [Manager subsystem 1402]
MoveAnalyst	Manager API [Manager subsystem 1402]
RemoveAnalyst	Manager API [Manager subsystem 1402]
MoveInfoFrame	Manager API [Manager subsystem 1402]
RemoveInfoFrame	Manager API [Manager subsystem 1402]
EmptyTrash	Manager API [Manager subsystem 1402]
GetChildFolders	Folder API [Manager subsystem 1402]
GetInfoFrames	Folder API [Manager subsystem 1402]
GetAnalysts	Folder API [Manager subsystem 1402]
RemoveFolder	Folder API [Manager subsystem 1402]
RunAnalystNow	InfoFrameGeneration API [Server API subsystem 1403]
ViewInfoFrame	InfoFrame Viewer Window [User Interface subsystem 1401]
run AnalystBuilder dialog	Analyst Builder [User Interface subsystem 1401]

The fourth Manager Window, Pending Queue, uses the following services from other subsystems:

Function Used	SubSystem
GetStatus	InfoFrame Generation API [Server API subsystem 1403]
CancelAnalyst	InfoFrame Generation API [Server API subsystem 1403]

Each of the four Manager Windows 1512 is controlled by a frame object and one or more control objects placed within the frame. In all four cases, the frame is represented by just one class, clnt_ManagerWnd, a subclass of CMDIChildWnd from MFC. The clnt_ManagerWnd object is parameterized on instantiation to indicate which control object(s) it should construct. As the superclass would suggest, it behaves as a standard MDI Child Window.

The control objects within the frame window inherit from MFC classes which are, in turn, wrappers for standard MS-Windows Controls. Classes clnt_AnalystCtrl, clnt_InfoFrameCtrl, and clnt_PendingCtrl each inherit from CListCtrl, and display their data in "columned" lists. Class clnt_FolderCtrl inherits from CTreeCtrl to display the tree-like hierarchy of the MDT Folders. These classes are instantiated, as needed, by the clnt_ManagerWnd, depending on the "style" flag it receives: clnt_AnalystCtrl is used

in ANALYSTS mode and FOLDERS mode; clnt_InfoFrameCtrl is used in INFOFRAMES and FOLDERS modes; clnt_FolderCtrl is used in FOLDERS mode and by the clnt_SaveAs dialog box (a part of the Analyst Builder); clnt_PendingCtrl is used in PENDING mode.

When the User **1405** begins a drag-and-drop operation, the source window of the drag constructs an instance of clnt_DragWnd, which then controls the remainder of the drag-and-drop. The clnt_DragWnd is given a pointer to the object or list of objects being dragged, and also an indication of the type of object being dragged. It then sends a message to any window the cursor passes over, asking whether it is "OK" to drop the object in that window. The windows which support drops are clnt_FolderCtrl and clnt_Toolbar (see section 3.2.3). When the User **1405** releases the mouse **21** button, the clnt_Dragwnd sends a message to the destination window requesting it to accept the dropped item(s), and also sends a message to the source window indicating that the drop was completed.

The Manager subsystem **1402** handles all functions related to manipulating, storing, and retrieving Folder **100** hierarchies, and the InfoFrames and Analysts that are stored in those Folders. Because all functions related to storing and retrieving this data are encapsulated in the Manager subsystem **1402**, there will be minimal impact on the other Client subsystems if the Folders/InfoFrames/Analysts data store moves onto the Server tier **32** in an alternate embodiment of the present invention.

As can be seen FIG. **15**, the Manager **1402** provides four APIs: Manager **1521**, Folder **1522**, Analyst **1523**, and InfoFrame **1524**. These APIs correspond to four classes which are described in the following sections. The main class in the Manager subsystem **1521** is the clnt_Manager class. Three data object classes: clnt_Folder, clnt_InfoFrameRequest, and clnt_InfoFrame, are used by the clnt_Manager, and by other subsystems. Access to Manager functions normally begins with a call to the clnt_Manager itself, requesting a list of Folders, Analysts, or InfoFrames. The objects which are returned by these queries can then be displayed to the User **1405** for viewing and/or manipulating. Requests for changes to any of the data objects pass through the clnt_Manager, which handles storing the changes on disk and, as applicable, sending the changes to the Server API subsystem **1403**.

The Manager subsystem **1402** also provides a "TrashBin" capability; that is, when a request to delete an Analyst or an InfoFrame is received, the object is placed in the TrashBin, and not actually deleted until the next EmptyTrash command is received. The TrashBin is persistent between sessions of the Client **12**. The TrashBin is implemented as an instance of the clnt_Folder class.

There is exactly one instance **1521** of the clnt_Manager class in the Client application **12**. In order to ensure that only one instance will be created, and that it will be safely globally available, the class uses the "Singleton" design pattern (as described in Gamma, et al., *Design Patterns: Elements of Reusable Object-Oriented Software*, Addison-Wesley, 1995, ISBN 0-201-63361-2). In this pattern, the class provides a static member function which returns a pointer to the one instance of itself. The function automatically creates the instance the first time it is called. The constructor of the class is made protected, thus ensuring that the class is never instantiated elsewhere.

The clnt_Manager class handles the following requests from other subsystems:

Service Provided	Description
GetManager	Static class function which returns a pointer to the one instance of clnt_Manager. See above.
GetRootFolder	Returns pointer to top clnt_Folder object.
GetTrashBin	Returns pointer to TrashBin (actually a clnt_Folder object).
GetAllAnalysts	Returns a list of all Analysts, without regard to Folder hierarchy.
GetAllInfoFrames	Returns a list of all InfoFrames, without regard to Folder hierarchy.
NewFolder	Creates a new Folder; parameter indicates the parent for the new Folder; returns pointer to the newly-created clnt_Folder object.
RemoveFolder	Removes the given clnt_Folder object; all of its sub-folders, Analysts, and InfoFrames are also removed.
MoveFolder	Moves the given Folder to a new Parent Folder.
NewAnalyst	Stores a new clnt_InfoFrame Request object in the given Folder, sends to ScheduleAnalyst Server API, if a Schedule is present.
UpdateAnalyst	Stores changes to an existing clnt_InfoFrameRequest object, sends to UpdateAnalyst Server API, if a Schedule is present.
MoveAnalyst	Moves clnt_InfoFrameRequest object to a different Folder.
RemoveAnalyst	Deletes the given clnt_InfoFrameRequest object; if a Schedule is present, sends a CancelAnalyst to the Server API subsystem.
UpdateInfoFrame	Stores changes to an existing clnt_InfoFrame object (normally changes to its HTML data, when annotations are added or raw data is processed into a graph, for example.)
MoveInfoFrame	Moves the given clnt_InfoFrame object to a different Folder.
RemoveInfoFrame	Deletes the given clnt_InfoFrame object.
DrillDown	If requested DrillDown Frame is already generated, returns that Frame; if not, sends the Frame Generation request to Server API.
SaveInfoFrameAsMDTFile	Creates a file that can be e-mailed, etc. File is an "MDT InfoFrame File"—only useable by someone who has Client software 12.
SaveInfoFrameAsHTML File	Creates a file that can be e-mailed, etc. File is a standard HTML 3.0 file, viewable by any HTML Browser program. A parameter to the function indicates if ASCII or UNICODE output was requested by the User.
ImportMDTFile	Reads in a file previously created by SaveInfoFrameAsMDTFile command, stores it as an InfoFrame object in a Folder. The InfoFrame is then available for viewing through standard mechanisms.
EmptyTrash	Completely deletes all items currently in the TrashBin.

The clnt_Manager object uses the following services from other subsystems:

Function Used	SubSystem
ScheduleAnalyst	Analyst API [Server API subsystem 1403]
UpdateAnalyst	Analyst API [Server API subsystem 1403]
CancelAnalyst	Analyst API [Server API subsystem 1403]
GetStatus	InfoFrame Generation API [Server API subsystem 1403]
RetrieveFrame	InfoFrame Generation API [Server API subsystem 1403]

Instances **1522** of class clnt_Folder are instantiated and deleted only by the clnt_Manager object. Other subsystem

gain access to clnt_Folder instances starting with the clnt_Manager's GetRootFolder( ) or GetTrashBin( ) functions.

The clnt_Folder object handles the following requests from other subsystems:

Service Provided	Description
GetFolderName	Returns name of this Folder.
SetFolderName	Changes the name of this Folder.
GetChildFolders	Returns a list of clnt_Folder objects which are "children" of this Folder.
GetInfoFrames	Returns a list of clnt_InfoFrame objects which are stored in this Folder.
GetAnalysts	Returns a list of clnt_InfoFrameRequest objects which are stored in this Folder.
RemoveFolder	Removes the given clnt_Folder object; all of its sub-folders, Analysts, and InfoFrames are also removed.

Instances **1523** of class clnt_InfoFrameRequest are created by the clnt_Manager object (when restoring saved Analysts from disk) and by the clnt_AnalystBuilder dialog class (when creating a new Analyst or doing a SaveAs on a current Analyst). Other subsystems normally access Analyst objects by retrieving them from their Folder (clnt_Folder::GetAnalysts( )). Instances of clnt_InfoFrameRequest are only deleted by the clnt_Manager object.

The clnt_infoFrameRequest class handles the following requests from other subsystems:

Service Provided	Description
GetName	Returns name of this Analyst.
SetName	Assigns a new name for this Analyst.
GetRequestID	Return a unique request ID assigned by Manager
SetRequestID	Assigns a unique request ID to the Analyst Request
GetUserName	Returns the user name
SetUserName	Assigns a user name to the Analyst Request
GetFrameDef	Returns the clnt_InfoFrameDefinition object for this Analyst.
SetFrameDef	Updates the Analyst's FrameDefinition object.
GetSchedule	Returns the clnt_Schedule object for this Analyst.
SetSchedule	Updates the Analyst's Schedule object.
GetTrigger	Returns the clnt_Trigger object for this Analyst.
SetTrigger	Updates the Analyst's Trigger object.
GetContainingFolder	Returns the pointer to the containig foldr object
SetContaining Folder	Updates the pointer to the containing folder object

The clnt_InfoFrameRequest class does most of its work through three helper classes. The clnt_InfoFrameDefinition class stores a description of the InfoFrame Generation request that will be sent when this Analyst is run (or scheduled).

The clnt_infoFrameDefinition class handles the following requests from other subsystems

Service Provided	Description
GetFolderID	Return the Folder ID assign to the analyst by clnt_Folder object
SetFolderID	Assigns the Folder ID to the Analyst.
GetAnalysisType	Returns the type of analysis Selected for this request.
SetAnalysisType	Updates the type of analysis selected for this request.
GetTargetMeasure	Returns the target measure selected for this analysis. Required
GetComparisonMeasure	Returns the comparison Measure selected for this analysis. Required only for Measure Compariosn Analysis.
SetComparisonMeasure	Updates the Compariosn Meausre Selected for this analyisis. Required only for Measure Comparison Analysis
GetAdditionalMList	Returns a list of Additional measure Objects selected for this analysis. Optional.
SetAdditionalMList	Updates the List of Additional measure Objects slected for this analysis. Optional
GetTargetSegment	Returns the target segment selected for this analysis. Required
SetTargetSegment	Updates the target Segment selected for this analysis. Required.
GetComparisonSegment	Returns the comparison Segment selected for this analysis. Required only for Segment Compariosn Analysis.
SetComparisonSegment	Updates the Compariosn Segment Selected for this analyisis. Required only for Segment Comparison Analysis.
GetAdditionalSList	Returns a List of Additional Segment Objects selected for this analysis. Optional.
SetAdditionalSList	Updates the List of Additional Segment Objects slected for this analysis. Optional
GetPartitionList	Returns the List of selected target Partitions. Optional.
SetPartitionList	Updates the List of selected target Partitions. Optional.
GetParentPartition	Returns the target segment's parent partition. Required only if target segment is not top level segment.
SetParentPartition	Updates the target segment's parent partition. Required only if target segmetn is not top level segment.
GetTimeSlice	Returns the pointer to the timeslice object for this analysis Required.
SetTimeSlice	Updates the pointer to the timeslice object for this analyusis. Required.
Operator=	Copies the object into another

The clnt_InfoFrameTimeSlice class handles the following requests from other subsystems:

Service Provided	Description
GetPeriodType	Returns the type of timeslice selected for the request.
SetPeriodType	Updates the type of timeslice selected for the request.
GetAnalysisType	Returns the type of analysis selected for the request.
SetAnalysisType	Updates the type of analysis selected for the request.
GetYearType	Returns the type of year definition selected for the request
SetYearType	Updates the type of year definition selected for the request
GetTrendInterval	Returns the interval duration. Required only for Trend Analysis.
SetTrendInterval	Updates the interval duration. Reuired only for Trend Analysis.
GetDuration	Returns the time duration.
SetDuration	Updates the time duration.
GetNumDuration	Returns the number of durations.
SetNumDuration	Updates the number of durations.
GetBasePeriod	Returns the Specific Date's base period.
SetBasePeriod	Updates the Specific Date's base period.
GetBaseThruPeriod	Returns the Specific Date's thru period.
SetBaseThruPeriod	Updates the Specific Date's thru period.
GetCompPeriod	Returns the Specific Date's Comparison Period. Required only by Change Analysis.
SetCompPeriod	Updates the Specific Date's Comparison Period. Required only by Change Analysis.
Operator=	Copies one TimeSlice object inot another.

The clnt_InfoFrameSchedule class stores definition of a schedule for the Analyst.

The clnt_infoFrameSchedule class handles the following requests from other subsystems:

Service Provided	Description
GetNumInterval	Return Number of intervals the report should run.
SetNumInterval	Update the number of intervals the report should run.
GetInterval	Return the duration for the interval the report should run.
SetInterval	Updates the duration for the interval the report should run.
GetStartDate	Rutun the date to which the report is scheduled to start runing.
SetStartDate	Updates the date to which the report is scheduled to start running.
GetNumLimit	Retuns the number of time periods the reports is scheduled to run.
SetNumLimit	Updates the number of time periods the report os shceduled to run,
GetLimit	Return the duration for the number of times the report is shceduled to run.
SetLimit	Updates the duration for the number of times the report is scheduled to run.
GetScheduleFlag	Returns the enabling or disabling state of the shcedule.
SetScheduleFlag	Updates the enabling or disabling state of the schedule.
GetTriggerFlag	Returns the enabling or disabling state of the trigger definition.
SetTriggerFlag	Updates the enabling or disabling state of the trigger definition.
Operator=	Copies one Schedule object into another

The clnt_InfoFrameTrigger class handles definition of trigger conditions to be checked before the Analyst is run. The clnt_infoFrameTrigger class handles the following requests from other subsystems:

Service Provided	Description
GetTriggerList	Return a list of triggers defined by the analyst
SetTriggerList	Updates a list of triggers defined by the analyst
GetMessageFlag	Return the enable/disable state depending on user selection of the action to be taken. In this case a message will be generated if trigger becomes true.
SetMessageFlag	Update the state of the message generation action.
GetFrameFlag	Return the enable/disable state depending on user selection of the action to be taken. In this case a Frame will be genereated if trigger becomes true.
SetFrameFlag	Update the state of the frame generation action
GetAnalystList	Return a list of analysts to be generated if the trigger becomes true. If List empty, this action is not selceted.
SetAnlystList	Update the list of analyst to be generated if the trigger becomes true. If List empty, this action is not selected
Operator=	Copies the object into another

The class clnt_trigger contains a single trigger condition. A list of clnt_trigger objects will be ANDed and defined as a single trigger. The clnt_Trigger class handles the following requests from other subsystems:

Service Provided	Description
GetMeasure	Returns the measure selected.
SetMeasure	Updates the measure selecected
GetOperator	Returns the operator selected
SetOperator	Updates the operator selected
GetOperand1	Returns the first operand measure
GetOperand2	Returns the second operand measure if operator is Between or not Between.
SetOperand1	Updates the first operand measure

-continued

Service Provided	Description
SetOperand2	Updates the second operand measure if operator is Between or not Between.
GetValue1	Returns the first operand value
GetValue2	Returns the second operand value
SetValue1	Update the first operand value
SetValue2	Updates the second operand value, if Operator is Between or not Between.
Operator=	Copies the object into another

Each instance 1523 of clnt_InfoFrameRequest must have a clnt_infoFrameDefinition object; the clnt_InfoFrameSchedule and clnt_Trigger objects are optional.

Instances 1524 of class clnt_InfoFrame are instantiated by the clnt_Manager object (when restoring saved Analysts from disk or receiving a new Frame from the Server API). Other subsystems normally access InfoFrame objects by retrieving them from their Folder (clnt_Folder::GetInfoFrames( )). Instances of clnt_InfoFrame are only deleted by the clnt_Manager object.

The clnt_InfoFrame class handles the following requests from other subsystems:

Service Provided	Description
GetName	Returns name of this InfoFrame.
GetHTMLFile	Returns name of file containing HTML Frame data is stored.
UpdateHTMLFile	Informs InfoFrame that it's data file has been updated (may be required for annotation, drill-down, graph generation).

The Server API subsystem 1403 encapsulates all functions which require communication with the MDT Server 32 (DAI 14). This isolates the User Interface 1401 and Folder Manager 1402 subsystems from specific knowledge about the Client-Server interface, keeping them independent of minor changes, etc.

As seen in FIG. 15, the Server APIs 1403 can be divided into four API modules: Metadata 1531, InfoFrame Generation 1532, Data Warehouse 1533, and Session Management 1534. The Server APIs subsystem 1403 also includes a set of internal routines for talking to the CSM 1404, which are shared by the four APIs. Each module is described below.

The Metadata API 1531 handles all Client 12 requests to view or modify portions of the MDT Metadata 25. Again the Metadata 25 resides on the server 34, and the Client 12 retrieves pieces of the Metadata 25 as needed, via the DAI 14. (362)

The MetaData API 1531 provides the following services to other Client subsystems:

Service Provided	Description
GetDimensions	Returns a list of clnt_Dimension objects representing all Dimensions.
AddDimension	Add a new Dimension.
UpdateDimension	Update an existing Dimension.
DeleteDimension	Remove an existing Dimension.
GetDimensionPartitions	Returns a list of clnt_Partition objects for all Child Partitions within a given Dimension.
GetPartitions	Returns a list of clnt_Partition objects for all Child Partitions within a given Segment.
AddPartition	Add a new Partition.
Update Partition	Update an existing Partition.
Delete Partition	Remove an existing Partition.
GetSegments	Returns a list of clnt_Segment objects for all

-continued

Service Provided	Description
	defined Segments within a given Partition.
AddSegment	Add a new Segment.
UpdateSegment	Update an existing Segment.
DeleteSegment	Remove an existing Segment.
GetMeasures	Returns 3 lists: Basic Measures, Composite Measures, and all Measures which are accessible to the User (some Measures are used internally in the Client code).
AddMeasure	Add a new Measure.
UpdateMeasure	Modify an existing Measure.
DeleteMeasure	Remove an existing Measure.
GetMeasureRelationship	Retrieve a Measure Relationship.
AddMeasureRelationship	Add a new Measure Relationship.
UpdateMeasureRelationship	Update an existing Measure Relationship.
DeleteMeasureRelationship	Remove an existing Measure Relationship.
GetRelationships	Retrieve possible Relationship types for a given Attribute.
GetRange	Retrieve range of values for a given Attribute.

The Metadata API uses the Communications Services module (see below) to communicate with the CSM **1404**.

Several classes work together to provide the set of services listed in the table above. Class clnt_Dimension has public methods: GetDimensions (a static class method), AddDimension, UpdateDimension, DeleteDimension, and GetDimensionPartitions, AddDimensionPartition, DeleteDimensionPartition. Class clnt_Partition has public methods: GetSegments, AddSegment, DeleteSegment, UpdatePartition. Class clnt_Segment has public methods: GetPartitions, AddPartition, DeletePartition, UpdateSegment. Measure functions are represented by two classes: clnt_BasicMeasure and clnt_CompositeMeasure.

The InfoFrame Generation API **1532** contains all functions related to requesting that the DAI **14** run or schedule an Analyst, and retrieving status and completed InfoFrames from the DAI **14**. Functions in this API **1532** are used by the Manager subsystem **1402** and the User Interface subsystem **1401**.

The InfoFrame Generation API **1532** provides the following services to other Client subsystems:

Service Provided	Description
GetInfoFrameGenerationInstance	Returns a pointer to the one-and-only-one instance of clnt_InfoFrameGeneration.
GetStatus	Query the DAI for list of currently pending and/or completed InfoFrames.
RetrieveFrame	Retrieve a specific completed InfoFrame from the DAI.
RunAnalystNow	Send an InfoFrame Generation request to the DAI for immediate processing.
ScheduleAnalyst	Send an InfoFrame Generation request to the DAI with a schedule on which to run it.
UpdateAnalyst	Send the DAI a modification to an existing, scheduled Analyst.
CancelAnalyst	Cancel a previously scheduled InfoFrame Generation request.

The InfoFrames API **1532** also uses the Communications Services module to communicate with the CSM **1404**.

The InfoFrame Generation API **1532** functions listed above are public members of the clnt_InfoFrameGeneration class. The clnt_InfoFrameGeneration class will be instantiated only once, using the "Singleton" pattern (described previously).

The Data Warehouse API **1533** provides services related to setting up Metadata **25**, at which time the MDTA (Administrator) needs access to information about the schema of the Data Warehouse **24**. This API **1533** cis encapsulated in the clnt_Schema class. The Data Warehouse API **1533** provides the following services to other MDT Client subsystems:

Service Provided	Description
GetTables	Returns a list of names of Tables from the current Schema data.
GetColumns	Returns a list of names of Columns from a given Table.
GetPrimaryKeys	Returns a list of names of Primary Keys in a given Table.
GetForeignKeys	Returns a list of Foreign Keys in a given Table.
ForeignToPrimary	Returns a list of Primary Keys associated with a given Foreign Key in a given Table.
PrimaryToForeign	Returns a list of Foreign Keys associated with a given Primary Key in a given Table.
LoadSchema	Loads schema from server; returns True if successful.

The Data Warehouse API **1533** also uses the Communications Services module to communicate with the CSM **1404**.

The Data Warehouse API **1533** is encapsulated in the clnt_Schema class. The clnt_Schema class has public member functions which correspond directly to the API calls described in the table above. The LoadSchema function loads all of the Data Warehouse schema onto the Client for the other API functions to access. The schema is discarded after each use.

The Session Management API **1534** contains functions related to establishing a session with the MDT Server (and to closing the connection when exiting). This includes functions related to User and Password management. The Session Management API provides the following services to other MDT Client subsystems:

Service Provided	Description
GetSessionManager	Returns pointer to the one-and-only-one instance of class clnt_SessionManager.
Connect	Establish a connection to the Server and attempt to authenticate the given User Name and Password.
Disconnect	Orderly shutdown of our connection to the Server.
UpdateUserPassword	Change a User's password on the Server.

The Session Management API **1534** also uses the Communications Services module to communicate with the CSM **1404**.

The Session Management functions listed above are public member functions of class clnt_SessionManager. Class clnt_SessionManager is instantiated once and only once, using the "Singleton" pattern.

The Communication service encapsulates functions for talking to the DAI **14** via the CSM **1404**. These functions are shared by the four APIs **1531**, **1532**, **1533** and **1534** within the Server APIs subsystem **1403**. The Communications Services capabilities are encapsulated in class clnt_Communications, which will be a private superclass for all other classes in the Server APIs subsystem **1403**.

3. Data Abstraction Intelligence (DAI) Subsystem **14**

The data abstraction intelligence subsystem **14** is described in further detail below.

A key feature of the present invention (also referred to as Management Discovery Tool or MDT) is that it allows the

user 1405 to easily choose different levels of granularity in the viewing and understanding of the business objects of interest, and have these different levels reflected in InfoFrames generated by the MDT. For example, when the user 1405 thinks of the concept of product, he or she may mean all products marketed by the Enterprise, or, more likely, some interesting subset of all products. This subset can be defined by restrictions on the attributes of product, either a single restriction such as men's clothing (defined as the product Department=men's clothing), or multiple restrictions, such as expensive men's suits made by Christian Dior (similarly defined by restrictions on Department, Price, and Manufacturer).

One of the insights in the design of the present invention is the notion that such subsets form hierarchies, and that these hierarchies may provide a convenient and powerful way for the user to both think about their business and select relevant levels or granularities for the production of InfoFrames. An important technical point, but one that is kept partially hidden from the user 1405, is how related segments form partitions.

The Management Discovery Tool of the present invention sits on top of a data warehouse 24, a single logical, consistent view of an enterprise's data. Typically, there are many different ways to store data; that is, there are different table structures or schema for a given set of data. For most, if not all, enterprises, there exists a small set of fundamental data types that are the lowest level of granularity and correspond to, typically, specific entities like product, customer, transaction, and the like. These entities can be thought of as having a set of attributes associated with them, and these attributes can have values. In the relational model, this corresponds to a table of entities, with the attributes mapping into columns. Again, physically, they may be stored as several tables, but conceptually, this is what MDT is working with.

FIG. 16 illustrates the hierarchy formed by the user 1405 choosing the Department attribute 1601, then selecting segment Men's Clothing Department 1602 of the attribute; of choosing the Product-type attribute 1603, then selecting the segment Shirts 1604 of that attribute; the Manufacturer Attribute 1605, then Perry-Ellis 1606; and finally, the Size attribute 1607, and a particular partition 1608/1609. The final Business Segment of interest is: "Perry Ellis Men's Shirts". Note that this segment could have been reached in several different ways, in particular, by any order of relevant attributes.

This scheme creates several requirements for other parts of MDT. First, the attributes of each dimension must be available. Second, the legitimate values for each attribute must also be made available. For finite domains, these must be listed for the user 1405; for infinite domains, current minimum and maximum values may be useful. There is a subtlety here that can perhaps be avoided at first: the possible attribute values may not, in fact, be appropriate in all cases. In the above example, all Manufacturers may not make Men's Shirts. It may be possible to query the database for legitimate values, or store this information as additional metadata.

An important requirement of the present invention is to provide the ability to save and re-use user-defined segments. If "Perry-Ellis Men's Shirts" is an important category to the user 1405, he or she should be able to save that category and re-use it in the generation of InfoFrames. Our approach allows users to define segments and automatically keeps these segments in a hierarchy. The table below provides a set of named segments and their definition, i.e. the restrictions on their attributes. All segments are on the dimension "Product".

Name	Dept.	Maker	Type	Size
Men's Clothing	MC			
Men's Shirts	MC		Shirts	
Perry-Ellis Shirts		Perry-Ellis	Shirts	
Perry-Ellis Men's Shirts	MC	Perry-Ellis	Shirts	
Men's Pants	MC		Pants	
Large Men's Shirts	MC		Shirts	Large
Large Men's Pants	MC		Pants	Large
Gap Products		Gap		
Perry-Ellis Products		Perry-Ellis		
Guess Products		Guess		
Medium and Large Men's Clothing	MC			Medium + large
Small Men's Clothing	MC			Small
Small Men's Shirts	MC	Shirts		Small

The segments described above give rise to the segment hierarchy depicted in FIG. 17. Note that there is an inherent ambiguity in this structure: a given Business Segment can belong to several different partitions and have children beneath it whom are in several different partitions. For example, the Segment "perry-ellis-men's-shirts" belongs to two partitions. The first partition is on "perry-ellis-shirts" and uses the value "men's" to further discriminate (note the "Other" segment would now mean "perry-ellis-shirts-but-not-for-men". This segment is also part of a partition on "men's-shirts", and restricts the Manufacturer attribute to be perry-ellis. Here, the "Other" segment indicates "men's-shirts-made-by-everybody-but-perry-ellis".

In order to resolve the ambiguity, the notion of partition must be made explicit. Thus, FIG. 17 may be re-drawn as shown in FIG. 18 to include partitions (dark boundaries) and the "Other" segments. We now see from FIG. 18 that the notion of "partition" is just as important as the notion of "segment"; indeed, the two notions cannot be separated.

Referring back to FIG. 1, the MDT Data Abstraction Intelligence (DAI) subsystem 14 sits between the Client subsystem 12 and the Data and Schema Manipulation (DSM) subsystem 16. The DAI 14 (and the DSM 16) reside on the Applications Server 32 between the Desktop 30 and the Data Warehouse 24. The DAI 14 is responsible for instantiating user selected InfoFrames and managing several kinds of metadata used in this instantiation. This metadata represents (1) Dimensions and Measures that provide a customizable "dimensionalization" of the relational data in the warehouse; (2) Measure Relationships that provide explanatory text in the InfoFrame; and (3) metadata related to time. The DAI 14 also processes updates to this metadata that originate in the Client layer 12 and handles several other kinds of user updates, primarily by passing them through to the DSM 16 subsystem. Finally, the DAI 14 executes Alert requests from either the Client 12 or the Scheduler subsystem 18.

The design of the overall Client/Server envisions two kinds of DAI subsystems 14. The first kind of DAI 14 is needed to handle continual, synchronous requests for information from the Client 12. For example, the Client 12 may make a number of requests for metadata information during an active MDT session; the S-DAI (for Serial DAI) will handle these requests.

The second kind of DAI 14 will execute an Analyst, which may contain a trigger definition or an InfoFrame definition. This execution may take a relatively long time (e.g., hours) and will execute concurrently. This type of DAI 14 may be called the C-DAI, for Concurrent DAI. The

C-DAI is spawned by an S-DAI in response to an InfoFrame request and given all the information it needs. When it is finished, it will write the resulting InfoFrame into a server disk file.

FIG. 19 shows the general, high-level data flow between the DAI 14 and the other subsystems and components of the present MDT invention.

When a user logs onto the present invention, a Serial DAI (S-DAI) 14A is created to service various kinds of requests. All user requests from the Client 12 flow through the Client/Server module (CSM) 1404, which controls communication between Client 12 and Server 32. Requests for metadata, both read and update (write) requests, are handled by the S-DAI. Read requests cause the S-DAI to query the Data and Schema Manipulation (DSM) module 16 for metadata contained in the MDT metadata tables. The S-DAI handles update requests by using the "Classic subsystem", a system for managing heirarchical data structures available from Bell Laboratories of Lucent Technologies. The Classic subsystem may be used to check and properly position new user segments in the segment hierarchy. The Serial DAI also handles requests for previously generated InfoFrames, fetching them from the Server disk.

When a user requests that an Analyst be generated, a Concurrent DAI 14B is created by the Dispatcher (if resources permit), and the Concurrent DAI 14B is passed all the information in the Analyst definition. The Concurrent DAI 14B then uses its built-in algorithms and metadata requested from the CSM 1404 to generate the InfoFrame which is then stored on the Server disk.

The CSM module 1404 provides the low level services that pass messages from one process to another. Certain classes may be built on top of the CSM 1404 that make it easier to use, as described in further detail below.

The message-passing design consists of 5 classes and an enumerated type. mdt_MessageType, the enumerated type has a unique value for each type of message in MDT; mdt_TInStreamHandle and mdt_TOutStreamHandle are handles for incoming and outgoing message streams respectively; mdt_Message is an abstract base class for all MDT messages; dai_MessageHandler is an abstract base class for objects that can handle messages; finally, dai_MessageRegistry is the registry of message handlers.

mdt_MessageType is defined below.

```
enum mdt_MessageType {
        UNDEFINED,
        CS_LOGIN,
        SC_LOGIN_RESPONSE,
        CS_GENERATE_INFOFRAME,
        CS_GET_INFOFRAME_STATUS,
        SC_INFOFRAME_STATUS,
        CS_GET_INFOFRAME,
        SC_INFOFRAME,
        END_OF_ENUM
};
```

mdt_MessageType is an enum than defines all the message types understood by MDT processes. For each class derived from mdt_Message, there must be at least one value in mdt_MessageType. This declaration of mdt_MessageType is used by all components of MDT. The message types shown are only a sample. The message types currently defined below are only a sample. This definition will evolve as MDT code is written.

mdt_TInStreamHandle is defined below.

```
class mdt_TInStreamHandle : public csm_InStreamHandle {
 public:
  mdt_TInStreamHandle() : d_mtype(UNDEFINED) {}
  virtual void Connect(RWvistream *);
  mdt_MessageType GetMessageType() const;
 private;
    mdt_MessageType d_mtype;
};
```

mdt_TInStreamHandle is a typed handle for incoming (received) message streams. An mdt_TInStreamHandle is used to pick up an incoming message stream from the CSM module 1404. The mdt_TInStreamHandle automatically reads the message's type from the incoming message stream and provides a member function to get that message type. Users of mdt_MessageRegistry need not use this class.

mdt_TOutStreamHandle is defined below.

```
class mdt_TOutStreamHandle : public csm_OutStreamHandle {
 public:
  mdt_TOutStreamHandle(mdt_MessageType t) : d_mtype(t) {}
  virtual void Connect(RWvostream *);
  mdt_MessageType GetMessageType() const;
 private:
  mdt_TOutStreamHandle();
  mdt_MessageType d_mtype;
};
```

mdt_TOutStreamHandle is a typed handle for outgoing message streams. An mdt_TOutStreamHandle is used to send a streamed message out via the CSM 1404. The mdt_TOutStreamHandle has a message type and automatically writes it's message type to the stream so that the mdt_TInStreamHandle on the receiving end can decode the message type.

mdt_Message is defined below.

```
class mdt_Message {
 public:
  mdt_Message() : d_restoreVersion(0), d_restoreFlag(false) {}
  mdt_Message(const mdt_Message &);
  virtual mdt_MessageType GetMessageType() const;
  virtual int GetLatestVersion() const = 0;
  virtual void SetRestoreVersion(int restore Version);
  virtual int GetRestoreVersion() const;
  virtual void saveGuts(RWvostream &) const;
  virtual void restoreGuts(RWvistream &);
  virtual bool IsRestored() const;
 protected:
  virtual void SetRestoredFlag(bool);
 private:
  bool d_restoreFlag;
  int d_restoreVersion;
};
```

Requests and Replys are communicated between Client 12, Serial DAI 14A, Concurrent DAI 14B, Scheduler 18 and Dispatch 2513 by the Client/Server Module (CSM) 1404.

CSM 1404 implements an mdt_Message class which will be used for sending or receiving Requests or Replies. A receiving mdt_Message will contain an input stream. A sending mdt_Message will contain an output stream. A stream is a well known C++ construct which allows the user to 'stream' the elements of a long message into a buffer, or to stream the elements of the message out of a buffer.

Each of the Request and Replies implemented for the present MDT invention are represented by a message

derived frmo the mdt_Message base class and has appropriate functions for streaming itself into or out of a stream.

The CSM **1404** implements a csm_SimpleSocket and a csm_ServerSocket class. Each type of socket contains a TCP/IP socket. A TCP/IP socket is a well known API to a TCP/IP network. Other implementations are envisioned. Each type of socket can extract the stream buffer from a message and send it via the socket to a recieving csm_Simple or csm_ServerSocket, or can receive a stream buffer from a sending csm_SimpleSocket and install it in a message.

A csm_SimpleSocket is used to communicate messages between MDT subsystems in a committed, one to one relationship. A csm_ServerSocket is used to allow an MDT subsystem to accept messages from many other subsystems.

In FIG. **25**, the Client subsystem **12** will maintain a csm_SimpleSocket which it will use to request a SDAI subsystem **2512** from the Master subsystem **2511**, and which it will use thereafter to exchange messages with that SDAI subsystem. The Client **12** will use this socket whenever a user input to the Client **12** requires an exchange with the Server. In FIG. **25**, the Master subsystem **2511** will maintain a csm_ServerSocket to receive messages from any Client subsystem **12** which wants to request an SDAI subsystem **14A**. Excepting when the Master is activly starting or otherwise tending to the SDAI's, it will be listening at the csm_ServerSocket.

The SDAI subsystem **2511** will maintain a csm_SimpleSocket to exchange messages with the Client subsystem **12**. Except when it is actually implementing a Client request, the SDAI **14A** will be listening at its csm_SimpleSocket.

When the user **1405** submits an Analyst for immediate execution, the SDAI subsystem **14A** will construct a new csm_SimpleSocket to communicate the Analyst to the Dispatcher **2501**. When the user sumbits a Scheduled or Triggered Analyst, the SDAI will construct a csm_SimpleSocket to communicate the Analyst to the Scheduler **18**. The Scheduler **18** will maintain a csm_ServerSocket to collect Scheduled or Triggered Analysts from any and all SDAI subsystems **2511**. When the Scheduler determines the the time has come to launch a Scheduled or Triggered Analyst, it will construct a csm_SimpleSocket to communicate that Analyst to Dispatcher subsystem **2513**. Except when it is testing its Scheduled and Triggered Analyst lists or dispatching them, the Scheduler will be listening at its csm_SimpleSocket.

The Dispatcher subsystem **2513** will maintain a csm_ServerSocket to collect Analysts for execution from any ready SDAI subsystem **2511** or from the Scheduler subsystem **18**; or to collect Analyst requests from the CDAI subsystem **14B**. When an SDAI or the Scheduler presents an Analyst, the Dispatch will hold it until resource become available for its execution. When resources are available the SDAI will start a CDAI **14B**. When the CDAI returns a request for the Analysts, the SDAI will create a csm_SimpleSocket to communicate that Analyst to the CDAI. Except when it is starting managing CDAIs, the SDAI subsytem **2513** will be listening at its csm_ServerSocket.

The CDAI subsystem **14B** will construct a csm_SimpleSocket shortly after it is started to collect its Analyst from the Dispatcher subsystem **2513**. After collecting this message, it will discard the csm_SimpleSocket. The CDAI **14B** will exchange no other messages with the other subsystems of the present invention.

The mdt_Message abstract base class defines the object that holds the content of an MDT interprocess message. Each message has a message type, a message version, and the ability to read/write its data from/to a stream of message data. For each type of message, there is a concrete implementation of a class derived from mdt_Message. Each message class must implement GetLatestVersion to return its version and GetMessageType to return its mdt_MessageType. It must also implement the Rogue Wave saveGuts and restoreGuts methods to write its persistent member data to a stream and read the member data back from stream. Unpacking order is first in first out. There is only one derived message class per message type, but there can be several message types used by a derived message class. The same message code should be linked into both the sending and receiving processes. Version checking is used to robustly handle mismatches between the version of the code in the sending process and the receiving process. The message version is used by restoreGuts to insure that an incoming message stream can be restored and to migrate streams saved by older versions of the class to the current version. An mdt_Messages is sent/received from the CSM module **1404** by saving/restoring its guts to/from the stream pointed to by the mdt_TOutStreamHandle/mdt_TInStreamHandle class defined above.

dai_MessageHandler is defined below.

```
dai_MessageHandler is defined below.
class dai_MessageHandler {
 public:
  virtual bool HandleMessage(const mdt_Message &) = 0;
};
```

dai_MessageHandler is an abstract base class for message handler classes. If the process uses the message registry to dispatch received messages, at least one concrete message handler class must be implemented. As many as one message handler per registered message may be implemented.

dai_MessageRegistry is defined below.

```
class dai_MessageRegistry {
 public:
  dai_MessageRegistry( csm_Connect &);
  void DispatchMessage();
  void RegisterMessage(mdt_MessageType,
                 dai_MessageCreateFunc,
                 dai_MessageHandler &);
 private:
  dai_MessageCreateFunc d_createFunc;
  dai_MessageHandler *d_handler;
  csm_Connect *d_connect;
};
```

dai_MessageRegistry is a class meant to be instantiated only once in each process that uses it. The message registry provides a method to register a handler for each message type and a method to dispatch all incoming methods. The dispatch method acts as the application's main loop. The return value of the HandleMessage method of the handler determines whether DispatchMessages blocks or returns after a message is processed. If the return value is true, it blocks.

The following is the set of events that occur as a message is transmitted from one process to another using the MDT typed stream handles and the message registry.

1. sending process constructs an instance of a concrete message class (derived from mdt_Message), MS and loads it with the proper message data.

2. sending process creates an mdt_TOutStreamHandle object with the same message type as the message. The mdt_TOutStreamHandle object writes the message type to the stream.
3. sending process uses the message's saveGuts member function to write the message to the message stream.
4. message's saveGuts method first calls base class method which writes the message's version number to the stream. Next it saves the message's persistent member data fields to the stream.
5. sending process calls csm_SendProcessConnect::Send( ) to send the message stream.
6. The CSM extracts bytes from the stream object and sends the bytes to the receiving process.
7. When the mdt_TOutStreamHandle object is destroyed, it in turn destroys the stream object it was connected to.
8. The receiving process should be waiting in a call to csm_ReceiveProcess::Receive( ). Internally, there is probably some queuing of messages.
9. The CSM in the receiving process gets the oldest queued message. It then converts the bytes into a stream object and connects that stream to the mdt_TInStreamHandle object that was passed to csm_ReceiveProcess::Receive( ).
10. When the stream is connected to the handle, the handle reads the message type from the stream and remembers it.
11. Finally, control returns from csm_ReceiveProcess::Receive( ) to the caller.
12. The receiving process gets the message type from the mdt_TInStreamHandle and constructs an empty instance of the right type of message class for that message type. If the message dispatcher is in use, this is handled by dai_MessageRegistry::DispatchMessages( ).
13. The receiving process calls the message's restoreGuts function. If the message dispatcher is in use, this is handled by dai_MessageRegistry::DispatchMessages( ).
14. The message's restoreGuts method first calls the restoreGuts method of its base class (usually mdt_Message) which reads the version number and saves it as the RestoreVersion member. Next control returns to the derived version of restoreGuts. It calls GetRestoreVersion and uses the resulting version number to determine which data members to read from the stream and what order to read them in. Next the data fields of the message class are read back from the stream.
15. The received message is now in its final form. If the dispatcher is in use, it looks up the handler for this message type in the registry and calls its HandleMessage method.
16. When the mdt_TInStreamHandle object used to receive the message is destroyed (or reconnected by another call to csm_ReceiveProcess::Receive( ), the stream it was pointing to is deleted.

The present MDT invention enables business or other users to monitor their data warehouse **24** by defining powerful report-generation objects called Analysts. An Analyst is an encapsulation of a generic type of business analysis, customized by the user **1405** by providing a set of parameters, a schedule, and a trigger condition. The Analyst periodically checks the trigger condition if it has a trigger condition, or periodically executes on the schedule if it has a schedule. Otherwise it executes right away. InfoFrames contain a variety of kinds of business data and hyperlinks which can be used to run other Analysts and generate related InfoFrames. The functionality of MDT, including Analyst definition and InfoFrame generation, requires an "MDT view" of the data warehouse **24** that we refer to as "MDT metadata" **25**.

The word "metadata", in general refers to various kinds, of "data about data" in a database or data warehouse **24** (FIG. 1). MDT metadata **25** provides a customizable view of the data not restricted by the relational structure of the database. MDT metadata **25** is stored in the data warehouse **24** as a set of tables and is read by MDT present invention during start-up. Populating the metadata **25** in the warehouse **24** is a key part of the MDT installation process, and an MDT Administrator will generally be needed to extend and maintain the MDT metadata using knowledge of the structure of the data warehouse **24**.

There are 4 main kinds of MDT metadata: (1) Dimensions and Attributes, (2) Segments and Partitions, (3) Measures, and (4) Measure Relationships. The present specification describes each kind of Metadata with a series of tables. Each table shows the column names and the types of the data values in that column (in parentheses). Some columns define MDT-oriented entities or objects, and others provide mapping information between MDT metadata and the relational schema of the warehouse. Primary keys for each table are italicized (if more than one column name is italicized, the combination of those column names forms the key).

MDT metadata **25** includes an explicit notion that certain data attributes can have a finite set of values. These are referred to as "enumerated attributes". For example, the present invention can represent the fact that the values for the attribute "State" are limited to a finite set of values (that is, each of the 50 States of the United States, in whatever encoding the data warehouse uses). The MDT metadata tables also refer to, for convenience, sets of values that are represented in enumerated types in source code header files. The word "enum" refers to column values of this type.

The table representation of MDT metadata **25** is first described in 4 sections, one for each main kind of Metadata. The following are then described: representation of time in MDT, the kinds of metadata that need to be stored in source code header files, and the issue of populating the metadata tables during installation is discussed.

Dimensions are the starting vocabulary for the domain: they define the high-level categories of entities. For example, in a retail domain, the Dimensions might be: Product, Market, and Time (Time is a universal Dimensions applicable to most domains and is discussed in a later section). Each Dimension has a set of attributes that can be used to describe its entities; for example, the various attributes for Product, like Department, Price, Style, and Manufacturer.

All tables in this section are set up during installation and are unlikely to change often, because they are all heavily dependent on the structure of the data warehouse **24** and the industry-specific view of the data. None of the tables in this section are generally modifiable by the end user, although occasional modification may be needed by the MDT Administrator to extend MDT metadata or respond to changes in the relational schema of the data warehouse.

As shown in the following table, dimensions are represented by their name and an associated Id. The Id is used to join with other tables more efficiently. The Seg-Id is the Id of the top-level segment for this dimension, and the Comment is a comment.

7256jDim-Id (int)	Name (string)	Seg-Id (int)	Comment (string)
001	Product		
002	Market		
...			...

The following table represents all of the attributes for each Dimension. Each attribute has a unique Id (Attr-Id), a name, and the Id (Dim-Id) of the Dimension they belong to. Attributes for different Dimensions can have the same name (but they will have different Ids). MDT-Type indicates the MDT type of the attribute. Each attribute is mapped to a single table and column, and we encode the data type of the field in the database that each attribute maps to (Column-Type). All the attributes for a given Dimension can be extracted from this table using the Dim-Id field. The enum values for MDT-Type are: enum, int, float, restricted-int, restricted-float, string. The enum values for Column-Type are all those types supported by the data warehouse.

Attr-Id (int)	Min (float)	Max (float)
"income"	0	1000.00

A key part of the MDT metadata **25** are a set of segments and partitions for each Dimension. A segment is a set of attribute restrictions that define a class of objects of interest. For example, "Stores remodeled less than one year ago", or "non-seasonal store-wide promotions", or "Perry-Ellis shirts of size 14 and larger". Segments are arranged in hierarchies, one for each Dimension. The hierarchies are further organized using the concept of a partition: a set of related segments differing only by the restriction on a single attribute. Segments and partitions are represented by a set of tables that capture the segment/partition hierarchy for each Dimension and define the attribute restrictions for each table.

The following table names each segment and the Dimensions it is a part of, and provides the name and the owner of the segment. The Owner string for segments that are glo-

Attr-Id (int)	Name (string)	Dim-Id (int)	MDT-Type (enum)	Table (string)	Column (string)	Column-Type (enum)	Comment (string)
006	Manufacturer	001	enum				
016	Size	001	int				
0057	Region	002	enum				
017	Department	001	enum				
0099	Size	002	float				
—	—	—	—				

With respect to attributes that are enumerated types, the following table represents the legitimate values for these attributes. These values will have both a user name, like "Men's Clothing" and the name of the actual data value, like "Dept-017". The information in these tables can be partially generated by a "Select . . . Distinct . . . " query for the attribute.

Attr-Id (int)	Display-Name (string)	Data-Name (string)
0017	Men's Clothing	Dept-017
0017	Housewares	
0017	Hardware	
0057	Southern	
—	—	—

For attributes that have type integer, the following table defines the appropriate ranges of values and a "typical value" if this would be useful to present to the user. Not all integer attributes have to appear in this table, if they do not have natural ranges and typical values.

Attr-Id (int)	Min (int)	Max (int)
"age"	0	120

For attributes that have type float, the following table defines the appropriate ranges of values and a "typical value" if this would be useful to present to the user. Not all float attributes have to appear in this table, if they do not have natural ranges and typical values.

bally owned will be defined in a header file; here and elsewhere it is shown as "ALL". There is a so-called "top-level segment" for each Dimension with the name "All X", where X is the Dimension name. The Num-Attrs field contains the number of attributes used to restrict this segment. For the "top-level segments", Num-Attrs will be equal to 0.

Seg-Id (int)	Dim-Id (int)	Name (string)	Owner (string)	Num-Attrs (int)	Comment (string)
112	001	Men's Clothing	ALL		
26	001	Men's Shirts	ALL		
14	001	Perry-Ellis Shirts	pgs		
117	001	Perry-Ellis Men's Shirts	pgs		
—	—	—	—		

The following table represents all the numeric attribute restrictions for each segment represented in the following interval notation. In the first row above, if Attr-Id 017 stands for the Attribute "Size", then this row would read: "0<=Size<=100"; that is, "Size is greater than 0 and less than 100". Values are represented as Strings so restrictions of attributes of other type (like float or currency) can also be represented. The enum values of Operator-1 are: greater than, less than, greater than or is, less than or is, is, is not, is between.

Seg-Id (int)	Attr-Id (int)	Value-1 (float)	Operator-1 (enum)	Value-2 (float)
112	017	0	"between"	100
112	018			
14				
117				
—	—	—	—	—

The following table represents all the set or enumerated type attribute restrictions for each segment. The The "Data Name" column is the same as before. For example, one might represent the segment "East Coast Cities" and define it as the set {New York, Boston, Washington, . . . }. To do this, several entries, one for each city, would appear in this table. This table can also be used to represent string attribute restrictions. The enum values for Operator are: is, is not, is in list, not in list.

Seg-Id (int)	Attr-Id (int)	Operator (enum)	Data Name (string)
112	019	"in list"	Seattle
112			
14			
117			
—	—	—	—

The following table defines each partition and the attribute it is defined over. The default partition name is that same as that of the attribute it is defined over. In this case, the user interface will display the partition name by appending "by-" as a prefix. The Name can be updated by the user **1405**.

Prtn-Id (int)	Name (string)	Owner (string)	Attr-Id (int)
59		ALL	0059
117		pgs	0017
—		—	—

The following table and the next define the segment/partition hierarchy. This table represents the child partitions of each segment. This table can also be used to find the parent segments for a given partition.

Seg-Id (int)	Prtn-Id (int)
112	59
13	117
—	—

The following table represents child segments for each partition. This table can also be used to find the parent partitions for each segment.

Prtn-Id (int)	Seg-Id (int)
19	15
221	222
—	—

Measures are values in the data warehouse **24** that can be measured over the data. For example, Sales, Price, and Market Share are all measures in the retail domain. Different Measures are "rolled up" differently; for example, Sales over several markets are added while Market Share is averaged. The present MDT invention provides a set of Basic Measures during installation and allows the user to combine them to form more complicated Composite Measures using formulas.

The following table names the Measure, defines its rollup mechanism, and maps the Measure to a table and column. The Display Units column is for InfoFrame generation only. Precision is the number of digits needed to the right of the decimal point. The enum values for Rollup are: add, average, count.

BM-Id (int)	Name (string)	Rollup (enum)	Table (string)	Column (string)	Display units (string)	Precision (int)	Comment (string)
055	Sales	add					
0917	Discount factor	average					
—	—	—					

Composite measures are built by combing basic measures, certain binary and unary operations, and special keywords that indicate, for example, the target segment, the child segments of a partition, or the sibling segments of a target segment. In addition, one can encode a set of segments to restrict a measure, using the next table. The Left-Arg and Right-Arg encode the kind of argument in "Left-M" or "Right-M", as shown here:

1. Basic measure
2. Composite measure
3. "Target segment"
4. "Parent segment"
5. Segment list: 2d argument is the Slist index (see next table).
6. Sibling segments
7. Child segments

If the operator in Op is a unary operator (count, sum, average), then only the Left-M is used. If the operator in Op is a binary operator (+, −, etc.), then both the Left-M and Right-M are used.

CM-Id (int)	Owner (string)	Name (string)	Display Units (string)	Left-M (int)	Left-Arg type (enum)	Op (enum)	Right-M (int)	Right-Arg type (enum)

If the Composite Measure references a list of segments, then the elements of the list are represented in the following table.

Cm-Id (int)	Seg-Id (int)
17	5
17	6

The following table is used to join an attribute with a basic measure to evaluate a dimensional query. The idea is that, for each attribute (that maps to a table and a column) and for each measure (that also maps to a table and a column), you need to be able to join their two tables. This table gives the column names for the two equivalent columns (keys) that can be used in the join.

Attr-Id (int)	Bm-Id (int)	Attr-Column (string)	BM-Column (string)
5	8	"cust_age"	"mkt_share"

The following table is used to join two attributes together to evaluate a dimensional query. That is, if the previous table (above) is not sufficient to join all attributes in a dimensional query to the measure, this table can be searched to try to find a path of attributes that can be used to create multiple joins to combine all attribute tables with all measure tables.

Attr1-Id (int)	Attr2-Id (int)	Attr1-Column (string)	Attr2-Column (string)
17	4	"cust_age"	"age"

A Measure Relationship is a qualitative description of causality between Measures. For example, in general, if "Shelf Space" for a product goes up, then one would expect "Sales" to go up as well. In this example, "Shelf Space" is the independent Measure and "Sales" is the dependent measure. However, Measure Relationships are more complicated than a simple statement of causality and direction. One would not expect the above example to hold over all values of "Shelf Space" but only some range of values. Similarly, one might expect the relationship to hold only if the "Shelf Space" increased by some reasonable percent. Also, one might expect a measure relationship to hold only for some segments but not for others.

The following table defines basic Measure Relationships as follows. The value for the column I-Direction is either "direct" or "inverse", an enumerated type defined in a header file. If the value is "direct", then if the Independent Measure goes up, the Dependent Measure should go up. If the value is "inverse", then if the Independent Measure goes up, the Dependent Measure should go down. The enum values for I-Direction are: direct, inverse.

MR-Id (int)	Owner (string)	Indepedent M-Id (int)	I-Direction (enum)	Dependent M-Id (int)
019	PGS	5	"direct"	21

The following table restricts the Measure Relationship to a certain range of values of the Independent Measure. The Operation can be >, <, >=, <=, =, not=, or between. For between, both Value-1 and Value-2 are used. The enum values for Operation are: is less than, is greater than, is less than or =, is greater than or =, is, is not, between, not between.

MR-Id (int)	Operation (enum)	Value-1 (float)	Value-2 (float)
019	"between"	5	100

The following table applies only to Measure Relationships with the Change Analysis Analyst definitions. It restricts the Measure Relationship to apply only when the Independent Measure changes appropriately over the time period of the Change Analysis. The enum values for Direction are: increases, decreases.

MR-Id (int)	Direction (enum)	Value (float)	Unit (string)

The following table restricts the applicability of Measure Relations by segment. Note that if a Measure Relation applies to a given segment, it will also apply to all children segments.

MR-Id (int)	Seg-Id (int)
055	19
—	—

Time is an important part of MDT metadata **25**. At one level, we would like the user to think of Time as another Dimension; however, because Time segments can be created on-the-fly (for example, the segment "Year-to-Date"), they are represented differently. We show this representation as a set of tables, although some of the information may be defined in source code header files.

The following table defines the lowest unit of granularity of time represented in the data warehouse **24**. We are assuming that all representations of time in the data warehouse uses this single unit of time. The enum values for Base Unit are: day, week, month, year.

Base Unit (enum)
Day

If a database table is used by a measure, that table must have a column for time in it. The following table lists the columns for each table that represent time, for each basic measure.

Table (string)	BM-Id (int)	Column (string)
Transaction		Time-stamp

The following table defines the different notions of year that may be important to the user **1405**. The enum values for Week Start Day are: Sunday, Monday, Tuesday, . . . , Saturday.

Name (string)	Start Month (string)	Start Day (int)	Week Start Day (enum)	Comment (string)
Calendar	January			
Fiscal	May			

Jan Start (int)	Feb Start (int)	Mar Start (int)	Apr Start (int)	May Start (int)	Jun Start (int)	July Start (int)	Aug Start (int)	Sept Start (int)	Oct Start (int)	Nov Start (int)	Dec Start (int)

Quarter 1 Begin Month (int)	Quarter 1 Begin Day (int)	Quarter 2 Begin Month (int)	Quarter 2 Begin Day (int)	Quarter 3 Begin Month (int)	Quarter 3 Begin Day (int)	Quarter 4 Begin Month (int)	Quarter 4 Begin Day (int)

The Serial DAI (S-DAI) **14A** (FIG. **19**) is responsible for providing access to MDT metadata **25** to each Client **12**. When a Client **12** logs into MDT, a Serial DAI **14A** is created and connected to the Client session. All Client requests for metadata, including update requests, are handled by the Serial DAI **14A**. In addition, the S-DAI **14A** provides access to the MDT Administrator, allowing him or her to configure MDT using the setup screens.

The architecture of the Serial DAI is shown in FIG. **20**.

The Serial DAI **14A** gets requests in the form of MDT messages from the Client **12**. Each MDT message has its own "reply class" in the S-DAI **14A**. Messages for metadata access and simple update are handled through the Metadata table interface of the DSM **16** (that is, without using the Classic component **14AA**—defined further below). Requests to add or delete segments use the Classic component **14AA** to validate the request and update the hierarchy as needed.

Metadata access and simple update services are provided to the Client **12** by the Serial DAI **14A** without use of the Classic component **14AA**. Whenever the Client **12** needs a particular piece of Metadata, typically to present in the user interface, the Client **12** will send a request message to the S-DAI **14A**. The S-DAI **14A** will access the appropriate Metadata tables **25** to extract the appropriate Metadata. It will then package it up and return it to the Client **12** in one or more messages. The Metadata interface automatically provides access to public metadata and the metadata for this particular user.

The general flow of data and control is shown in FIG. **21** and described below.

[step **2101**] The Client **12** sends a metadata request message to the S-DAI **14AA**. This message includes the the message type and the required parameters.

[step **2102**] The Serial DAI **14A** examines the message type and determines which Metadata table **25** is needed.

[step **2103**] Using the parameters, the S-DAI scans the Metadata table(s) **25** for the correct metadata.

[step **2104**] The Serial DAI **14A** packages the metadata up.

[step **2105**] The Serial DAI **14A** sends a metadata message back to the Client **12**.

In the unlikely event of an error, the S-DAI **14A** will log the error in the server error log and return an error code to the Client **12**. There may be several kinds of errors of varying severity.

New Composite Measures are added from the Client **12** using the user interface. Any syntactic or semantic checking will take place there. The syntax for Composite Measures is shown above. When the Client **12** indicates that a new Composite measure has been created, the Serial DAI will add the information to the appropriate metadata table, discussed previously.

An existing Composite Measure can be updated by pulling up an existing measure in the Measure Builder screen, editing it, and hitting the Save button. The edited Composite Measure will be saved to the Metadata tables **25** using the same Composite Measure Id. The Client **12** will display a warning message to the user **1405** to the effect that, if this Measure is being used in an Analyst, the meaning of the results presented in the subsequent InfoFrame will be different.

A Composite Measure can be deleted if it is owned by the user. The Composite Measure and its formula entries will be deleted from the appropriate table, previously described. A warning message will be presented to the user **1405**, warning that if this Compound Measure is used by any Analyst or other Compound Measure, the subsequent InfoFrame will not be generated correctly and an "analyst-time" error will occur.

Adding a new measure relationship is similar to adding a new Composite measure. All checking, if any, will take place in the Client **12**. When the Client indicates that a new measure relationship has been created, the Serial DAI **14A** will add the information to the appropriate metadata tables.

Modifying a measure relationship is straightforward. The appropriate tables are updated and the measure relationship id is preserved. A Measure Relationship can be deleted if it is owned by the user **1405**. The Measure Relationship and its table entries will be deleted from the appropriate tables. A warning message will be presented to the user, warning that

if this Measure Relationship is used by an Analyst, the subsequent InfoFrame will not be complete and an "analyst-time" error will occur.

The Serial DAI **14A** also processes requests from the MDT administrator. These requests are used to install MDT and make occasional changes to the public metadata. The Serial DAI **14A** must handle the flow of information from both the data warehouse **24** to the Client **12** (sending both data warehouse schema information and metadata) and from the Client **12** to the data warehouse **24**, in this case exclusively to the metadata. The Serial DAI **14A** is not expected to have to do any processing on the data itself, i.e., to do additional integrity or exception checking.

The data warehouse schema is passed to the Client **12** in one uninterpretted bundle and the Client **12** will interpret it. There are eight steps to setting up or installing MDT. Each step involves the Client **12** getting information from the Administrator through the user interface and passing information to the S-DAI **14A**. The S-DAI **14A** will update the metadata tables through the DSM interface. These steps are:

1. define dimensions
2. define and map attributes to database columns
3. rename coded attribute values
4. create basic segments
5. define and map basic measures to database columns
6. review the joins between database tables
7. assign database columns as time markers
8. define year types

Classic **14AA** is used to represent the user's segment and partition hierarchy, as described previously. When a user adds, modifies, or deletes a segment, the Classic component **14AA** determines any and all changes that need to be made to the segment/partition hierarchy, or detects one of several possible kinds of errors. If there are no errors, these changes are then used to update the Client interface and the persistent metadata tables. This is shown in FIG. **22**:

[step **2201**] The Client **12** sends a segment update request, either an add, delete, or modify segment message.

[step **2202**] The S-DAI receives the request.

[step **2203**] It then calls the appropriate function in the Classic module, which uses Classic to determine all of the segment/partition changes the request induces.

[step **2004**] These changes (or an appropriate error condition) are returned; if there is an error, this is passed back to the Client with no changes to the Metadata tables.

[step **2205**] If there is no error, all changes are passed to the Metadata tables.

[step **2206**] Again, assuming no errors, an acknowledge message is sent to the Client.

[step **2207**] If the knowledge base is changed, the appropriate knowledge base file is updated.

The user's segment hierarchy is kept persistent in a knowledge base files on the Server disk. This is because it would be too time-consuming to re-create it each and every time from the Metadata tables. There is one knowledge base file for each dimension and each user. Each file reside in some area on the Server disk and be named "dimension. user".

The user **1405** adds a new segment by selecting an existing segment (perhaps the top level segment) and then selecting a sequence of attributes and restrictions. This sequence defines a sequence of partitions and attributes. Consider the set of attributes and restrictions of: {age>65, income>100K}. This segment might be called "Wealthy Seniors". This would give rise to the following sequence, assuming the segment was defined at the top level:

```
All Customers
[By-Age]                  <= partition named by its attribute
   Age>65                 <= automatically named intermediate egment
      [By-Income]
         Wealthy Seniors  <= user-defined and named segment
```

The order of attributes is very important. That is, the final segment, "Wealthy Seniors", could also have been defined by Income and then by Age, with the same resulting final segment. However, the automatically created intermediate segment, and the two automatically created partitions, would be different. (In this case, the first partition would be "By-Income", the intermediate segment would be "Income>100", and the second partition would be "By-Age").

The following guidelines are supported for the creating of new segments:

1. The final user-named segment is created
2. "Supporting" partitions and segments are automatically created and named but only in the attribute order generated by the user **1405**
3. If the final segment is a child of any existing partition it "appears there" as well.
4. If the final segment differs by a single attribute from an existing segment, the one intermediate supporting partition will be created.
5. If any segments are classified under the new segment and differ by just one attribute, the appropriate partition is created.

To illustrate guideline **4** above, let us assume the Customer hierarchy looks like this:

```
All Customers
   [By-Income]
      Moderate-Income
         High-Income
```

The user defines "Wealthy Seniors" as above. The hierarchy should now look like this:

```
All Customers
   [By-Age]
      Age>65
         [By-Income]
            Wealthy Seniors
   [By-Income]
      Moderate-Income
      High-Income
         [By-Age]
            Wealthy Seniors <=  segment and partition
                                automatically added
```

Likewise, when the user **1405** adds a new segment, if there is an existing segment that belongs under that segment, differing by a single attribute, the existing segment will be put under the new segment and the new partition will be created.

The segment/partition hierarchy is somewhat of a strange beast. It is rooted at the "top-level segment" for that dimension, which is a segment with no attribute restrictions (this is why it represents "ALL-X", where X is the dimension, like Customer or Product). Each segment has a number of child partitions. Each partition represents a seg-

mentation by a single attribute and has a number of child segments. A segment can belong to several partitions. A partition has only one parent segment.

The user **1405** creates a new segment by selecting a starting or parent segment, choosing a name for the final segment, and then entering a set of attributes and restrictions in the user interface. For each attribute restriction (in the order the user chose) a segment will be created and added to the segment/partition hierarchy. When a segment is added, partitions may need to be created both above and below the new segment.

FIG. **23** shows the addition of a segment (without loss of generality, one that differs from its parent by one attribute restriction). First, the new segment must be "fit" with a partition underneath its specified parent. If the new segment fits in an existing partition or partitions, it is added to those partitions (reference numeral **2301**). If not, a new partition is created, (reference numeral **2302**). As with all new partitions, other segments may fit and be added. For all other parents of the new segment (Classic will tell us all parents), we first make sure the new segment and parent differ by only 1 attribute. If so, as is true of the parent at reference numeral **2303**, we again add to existing partitions (reference numeral **2304**) or create a new one. (The Parent at reference numeral **2305** differs by more than one attribute. This means we don't know the order of the intervening segments, so we leave it alone.) Finally, any children segments of the new segment (like reference numeral **2306**) (Classic will tell us the children of a segment) are fitted with new or existing partitions, like reference numeral **2307**.

The following is a very brief sketch of the algorithm for adding a new segment to a user's hierarchy. When Classic **14AA** is used, this is indicated by underlining.

INPUT: a parent segment and a new segment (NEW). The new segment consists of a single added attribute restriction. When the user **1405** inputs more than one attribute restriction, this basic algorithm is called several times, with names generated for the intermediate segments.

```
create a temporary Classic segment for NEW
If NEW is identical to an existing segment return
/* for each parent:
    check that the level difference is one
    either add the segment to an existing partition or
        create a partition, add the segment, then add additional segments
*/
    get the parent segments of NEW
    for each Parent {
        if the level difference ==1 {
            fits_flag = FALSE;
            for each child partition of this segment {
                If the segment fits in this partition {
                    fits_flag = TRUE;
                    add the segment to the partition
                }
            }
            if (!fits_flag) {
                create a new partition under the parent
                add the segment to the partition
                for all other children of the current parent {
                    if the child fits this new partition
                    add it to the partition
                }
            }
        }
    }
/* Now that the segment has been added to all its parents:
```

For all children of the new segment:

```
            check to see the level difference is 1
            either add it to an existing partition or
            create one
    */
        Get the children of the segment NEW
        For each child {
            if the level difference == 1 {
            for each child partition of NEW {
                if child fits with partition {
                    add it to the partition
                    fits_flag = TRUE
                }
                else {
                    create a new partition under NEW
                    add the child to it
                }
            }
        }
```

Deleting a segment can be surprisingly tricky. That is because various changes in the hierarchy can occur when a single segment is deleted. By design, we require that children of a segment to be deleted are themselves deleted if no other partitions refer to them.

With reference to FIG. **24**:

```
FOR ALL PARENT PARTITIONS
    [2401] remove the parent/segment link
    [2402] if no other segment, delete the partition
    FOR ALL CHILDREN OF THE PARENT SEGMENT
        [2404] see if they "fit" the partition now
    FOR ALL PARENT PARTITIONS
        [2405] see if they are redundant and can be "collapsed"
    FOR ALL CHILD PARTITIONS
        [2406] remove the segment/partition link
        [2407] delete the partition
    FOR ALL CHILD SEGMENTS
        [2408] delete the child segment link
        [2409] if they have no parent partition, DELETE
    [2410] DELETE THE SEGMENT
```

Mention was previously made of an "other" segment (referred to herein as "OS") that represents those entities not captured by the explicit segments in the final partition. For example, in a hierarchy that looks like this:

```
All Customers
    [By-Age]
        Age>65
            [By-Income]
                Wealthy Seniors
```

the OS under the partition "By-Income" would represent people older than 65 but whose income does not make them wealthy.

The OS will not be represented explicitly in the hierarchy. This is because its definition will change depending on what segments exist. For example, if the user added a segment called "Middle class seniors", the definition of the OS would change. Rather, the OS is implicit and its attribute restrictions can be computed by taking the restrictions of its sibling segments and negating them.

The Classic knowledge base must be initialized from the persistent metadata tables **25**, either when a user **1405** first logs in or when a segment update request is received. Each dimension and its respective segments and partitions can be treated as a separate knowledge base. The initialization can be performed in two ways: (1) by making direct calls to Classic **14AA**, or (2) by creating an ASCII flat file that

Classic 14AA can read. The former is probably more efficient, while the latter may have advantages for debugging and retraction on error.

The general steps to create a Classic knowedge base are as follows, with reference to the table previously defined:

- For each Dimension, read from the Dimension Definition table
  - => define a dimension_filler individual for that Dimension
  - => For each numeric or string attribute
    - ◇ define the attribute role
  - => For each enumerated attribute
    - ◇ define the attribute role
    - ◇ define the primitive "filler"
    - ◇ for each enumerated attribute value
      - define the value individual
  - => For each segment definition
    - ◇ get all the attribute restrictions
    - ◇ define the segment
    - ◇ define the segment individual
  - => For all partitions
    - ◇ create a partition individual
  - => For all Segment to Child Partition mapping
    - ◇ create the mapping by adding the partition individual to the segment individual
  - => For all Partition to Child Segment mapping
    - ◇ create the mapping by adding the segment individual to the partition individual

The modification of metadata, including the addition, deletion, and editing (changing) of metadata by both MDT Business-level users and the MDT Administrator (or Analyst level user), will now be described.

To modify metadata means to change it. In one embodiment, there are three kinds of change supported by the Serial DAI 14A and the Client interface: addition, deletion, and editing. The kinds of metadata involved typically include segments, composite measures, and measure relationships. There are two kinds of users 1405 who modify metadata: normal (or "business level" users), and the MDT Administrator or Analyst Level user, both refered to in this document as the MDTA. The MDTA can usually, but not always, be thought of as another user editing public metadata. We are generally not concerned here with the MDTA changing other kinds of MDT metadata like the mapping and join information. The table below summarizes these combinations:

Subject	Action	Object
User	Add	Segments
MDTA	Delete	Composite Measures
	Edit	Measure Relationships
MDTA	Add	Dimensions
	Delete	Attributes
		Basic Measures

Modification of metadata is done through the Client interface, including the segment builder, measure builder, measure relationship builder, and some setup screens. The general flow of control is from the Client 12 to the Serial DAI (S-DAI) 14A, to the Classic component 14AA if segments are involved, and then to the metadata tables 25. Various warnings and errors may be presented to the user 1405, as appropriate.

Modification of metadata gets tricky for two reasons. First, their exist dependencies between metadata, for example, between segments and composite measures that refer to a segment, or dependencies between "public" metadata managed by the MDTA and various user's private metadata. Second, defined analysts, either scheduled or unscheduled, may refer to metadata that has been modified. Several important issues must be addressed, for example:

1. What happens when an analyst refers to missing metadata, i.e., metadata that has been deleted?
2. What happens when metadata is deleted and other metadata refers to it?
3. When the MDTA changes public segments, how are the user's segment hierarchies updated?
4. What happens when the MDTA deletes a dimension, attribute, or basic measure?

One can imagine two extreme approaches along a spectrum: one, do no checking whatsoever (a "user beware" approach), two, try to capture and prevent all potential problems. In a preferred embodiment, the present invention may be designed to be closer to the "user beware" side of the spectrum, although any other suitable design may be implemented. Given this, it is desirable to give the user 1405 warnings and information when available and to not do anything that surprises the user 1405 without warning and, if possible, confirmation.

The Concurrent DAI (CDAI) 14B (FIG. 19) is the MDT subsystem that generates InfoFrames. Its input is an InfoFrame Request from the Client 12 or Scheduler subsystems 18 and its output is an InfoFrame containing an external HTML text report contained in a file in the User Return Area. The working of the CDAI subsystem 14B, including how it is structured and the format of the resulting reports, are provided below.

The CDAI 14B may be a UNIX or NT process executing on the UNIX or NT Server platform. It is invoked by a Dispatcher component with the command line such as:

*mdt*queryengine [-*c* <config>] [-*e* <errlog>]

where the config name and the errlog name are optional Configuration file and Error Log names respectively, inherited by the Dispatcher from the Master's command line when the Master invokes it.

Certain features of the CDAI's 14B function may be determined by the value of attributes defined in a Configuration file. These attribute values specify the thresholds for Interestingness Heuristics, Localization Parameters and etc.

The CDAI 14B will generate an InfoFrame for the User and Error Logs for the MDT Administrator in the local text. The User's local (and language) may not be the same as the Administrator's however. For this reason, the CDAI 14B may reference two Message Catalogs to collect localized text. The Native catalog will be used as a source for localized text for InfoFrames. The Error catalog will be used as a source of localized text for the Error Log.

The text of the generated InfoFrame will be localizable. The localized names of Measures, Segments and Time Periods will be provided by the Client 12 or extracted from the Metadata. Other text will be kept as parameterized strings in an MDT Message Catalog. This is known as the Native catalog. The CDAI 14B will compute the name of the Native catalog from the value of the MsgCatalogPath attribute contained in the configuration file and the ISO language name provided by the client. A separate catalog must preferrably be kept to generate Error Logs in the MDT Administrators language.

The CDAI 14B will accept one mdt_InfoFrameRequest object in an RUN_ANALYST_REQUEST message. The Request may contain an InfoFrame Definition (mdt_InfoFrameDefinition), describing the InfoFrame to be generated. It may specify the type of the InfoFrame, the Segment(s) to be reported over, the Measure(s) to be

reported on and the Time Period(s) to report for. In one embodiment, there are five types of Reports. These are:

- Summarization—The basic analysis of a target measure over a target segment
- Change Analysis—Summarization of the difference of a target measure over two separate time periods and over a target segment
- Measure Comparison—Summarization of the difference between two measures over a target segment
- Segment Comparison—Comparison of the same measure over two separate target segments
- Trend Analysis—Report of trends over time in the target measure and related measures over the target segment and related segments

The Request may contain an InfoFrame Trigger (mdt_InfoFrameTrigger). The Trigger defines a test for some condition in the data warehouse **24** and an Alert flag and may contain a "nested" InfoFrame Request. If the Request contains a Trigger, the CDAI **14B** must only implement the InfoFrame Definition if the condition is true. If the condition is true, the CDAI **14B** must also, if the Alert flag is true, generate an Alert and, if the Trigger contains an nested Request, execute the nested Request.

In general, the CDAI's **14B** output will be an InfoFrame object containing a localized, extended HTML Report (see FIG. **12**). The InfoFrame will be written into a file in the User Return Area (defined below).

The User Return Area is a directory whose path is given by the UserReturnAreaPath parameter fo the configuration file. On successful completion of the InfoFrame, the report will be named INF.<UID>.<UNQ> where UID is a User ID and UNQ is some string which guarantees that this file name will be unique from all other file names generated for this User.

The Unique identifier will be generated by the Dispatcher when it launches the CDAI **14B** and will make it available to the CDAI **14B** with the InfoFrame request. As each Report requires a unique name, a CDAI **14B** instance can only generate one Report. Where an InfoFrame Request specifies more than one report, when a triggered request requires an Alert Report and 'other' Reports as well as 'the' Report, the CDAI **14B** accepting the request will need to dispatch new CDAI's **14B** to deal with this multitide of Reports.

The HTML extensions used to build the Report are described in further detail in Ser. No. 08/742,003, filed Oct. 31, 1996, and entitled "Hypertext Markup Language (HTML) Eextensions For Graphical Reporting Over An Internet" and assigned to NCR Corporation, also the assignee of the present invention and patent application. This Ser. No. 08/742,003, now U.S. Pat. No. 5,748,188, is incorporated herein by reference thereto.

These extensions will be interpreted by the Client viewer. The Report will contain either an InfoFrame Report, an Alert Report or an Error Report. An InfoFrame Report will be generated when the CDAI **14B** successfully completes an InfForame definition. It will be generated by the ifgn_Report class.

An Alert Report will be generated when an InfoFrame Request has a trigger and that trigger evaluates to true and the Alert flag is set. It will be generated by the ifgn_AlertFrame class.

An Error Frame will be generated when the CDAI **14B** is unable to evaluate a trigger or an InfoFrame definition and lives to tell about it. It will be generated by the ifgn_ErrorFrame class.

The content of the InfoFrame Report (see FIG. **12**) is highly variable, depending not only on the type of analysis required but on the values of the measures encountered. The Report may be organized in a variety of ways, such as a heading, four bulleted paragraphs, a table, etc. For example:

- Heading—Quotes the Analyst Description provided by the User when the Analyst is defined and names the Segments, Measures and Time Periods analysed and, if the Analyst had a trigger, the trigger terms and the time at which the trigger condition was satisfied.
- Target Segment(s) Report—A bulleted paragraph which contains:
- Target Segments—Text highlighting the results for the measure(s) over the segment(s) and time period(s) directly specified in the analyst definition. Additional measures are not reported in this section.
- Parent Contribution—A bulleted paragraph highlighting any significant contribution made by the target segment (s) to its parent segment. This section is not included when the target segment(s) is a top level segment or if the target measure(s) contains a reference to a parent segment.
- Sibling Comparison—A bulleted paragraph offering interesting comparisons of the target segment(s)' value to the values of its sibling segments. This section is not included when the target segment(s) is a top level segment.
- Sibling Graphs—A bar or pie chart showing the values of the sibling segments or a Line graph showing trends. This graph is not produced if there are Drill Down segments.
- Drill Down—A bulleted paragraph highlighting interesting relationships between the values of child segments in the drill down partition(s) to the value for the target segment. Drill Down partitions may be specified by the user in the analyst definition. If the user does not specify any drill down partitions, MDT automatically chooses one or more interesting partitions. See the section below on choosing drill down partitions to learn how they are automatically chosen. This section is not included when no child partition exists and no unrestricted attributes exist to create or if no existing or created partition is interesting.
- Drill Down Graph—A bar or pie chart showing the values for the Drill Down Sements or a Line chart showing trends. This graph is not produced if there are no interesting Drill Down segments.
- Formula Decomposition—A bulleted paragraph highlighting interesting contributions to the composite measure of its component measures. This section is included only when the target measure is a composite measure.
- Measure Relationships—A bulleted paragraph describing possible causes for the difference between two values of the target measure (or the difference between the target and comparison measures for the Measure Comparison Analysis). The Summarization Analyis will not contain a Measure Relations paragraph.

Table

A table showing all the measure values reported during the analysis

Segments other than the Parent, Target or Comparison segment may be marked as hyperlinks (see again, e.g., FIG. **12**). The underlying HREF will contain the information required to substitute this segment as the target segment for

a new analyst of the same type, for the same measure, comparisons and periods.

The Alert Report is much more straight forward. It's most interesting characteristic is the hyperlink to the Analyst Name. When the InfoFrame Request was defined, an Analsyst may have been defined to optionally gather more information on the event. By selecting the hyperlink, the User can launch this Analyst. The text of the Alert frame may look like:

```
Alert: <Analyst Name>
<Target Segment>
<Additional Segment 1>
...
<Additional Segment n>
<Base Time Period Description>
Alert was triggered at <time alert triggered>
Click here to run <Analyst Name>now.
Trigger is:   <Measure Name>[<Operator><Measure Name>],
              <Measure Name>[<Operator><Measure Name>],
              ...
              <Measure Name>[<Operator><Measure Name>]
```

An Error Report may be simpler still. It is meant to communicate exactly one statement to the User 1405, a description of the error encountered. The format may be:

```
Error: <Analyst Name>
An Error Occurred at <time error occurred>
<Error Test>
```

The CDAI 14B may report errors to a server error log. The texts of the error messages are maintained in the error message catalog as parameterized, localizable strings.

4. DSM Subsystem 16 and Scheduler Subsystem 18

The data and schema manipulation subsystem 16 and scheduler subsystem 18 are described in further detail below.

The MDT Server 32 may implement two classes of Requests for the User 1405.

- Interactive Requests; Metadata Fetch, Metadata Update, InfoFrame Scheduling, InfoFrame Status and etc. The Server will implement one Interactive Request at a time for each Client. That we handle one Interactive Request at a time is almost as interesting as that they are interactive so we will also call these Serial Requests.
- Batch Requests; Trigger Requests and InfoFrame Generation. The Server must be able to implement multiple Batch Requests at a time. That we must handle multiple Batch Requests at a time is almost as interesting as that they are batch so we will also call these Concurrent Requests.

Each Concurrent Request will cause one or more queries against the Database. The ODBC standard supports asynchronous queries against the database but many implementations of ODBC do not. In these implementations, each Concurrent Request will require its own process. Because putting each Request in its own process allows us to work with many more ODBC implementations and passes responsibility for managing the memory and data structures for multiple Requests to the operating system, each Concurrent Request will be get its own process. This process will be the Concurrent instance.

If Serial Requests and returning results are made to be asynchronous events, a single Server instance might be able to handle all of the Server's Serial Requests. But implementing asynchronously, while not overly difficult, is rather pointless when each Client 12 can simply be handed a new Server instance. Each Client 12 is therefore assigned a Serial instance to handle its Interactive Requests.

Its important to note that Windows NT implements threads, and future revisions of the UNIX operating system should as well. Threads provide an opportunity to pass responsibility for handling asynchronous events to the operating system while still managing memory in a single process.

Also, for purposes of the present invention description, it will be assumed that the Serial and Concurrent instances will be implemented by unique executables, each implementing a subset of complete Server functionality appropriate to its Requests.

With reference to FIG. 25, the Server 32 may be implemented as a collection of cooperating processes. There will be five classes of processes, as described below:

- The Master process 2511, responsible for accepting Client connections with the Server and assign the Client 12 a Serial instance.
- The Serial instance 2512, responsible for executing all of this Clients Serial Requests. These will be Metadata Fetches and Updates, InfoFrame Scheduling Requests and etc. The Serial instance will queue Scheduled InfoFrame Requests in the Scheduler's Queue. The Serial instance will also get the Client's InfoFrame Generation Requests, a Concurrent Request, but it will pass this on the Dispatcher.
- The Dispatcher process 2513, responsible for assigning a Concurrent instance to each Concurrent Request passed to it by the Serial instance or the Scheduler and for reporting the state of pending and executing Concurrent Requests.
- The Concurrent instance 2514, responsible for executing a single Concurrent Request.
- The Scheduler processes 18, responsible for passing InfoFrame Requests to the Dispatcher at the scheduled time.

Create relationships are indicated with white pointers 2501 from parent to child. Request relationships are indicated with black arrows 2502 from sender to recipient.

A process of the Server will share several resources in common to present a single state to the client. These are the Metadata, the Scheduler Queue and the Return Area.

When a User 1405 makes a change to the User's Metadata, that change must be visible to all of the User's subsequent InfoFrame Requests. When that User 1405 is the MDTA (Administrator) and the MDTA specifies changes to global Metadata, these changes must be visible to all subsequent Requests.

MDT's Metadata will be stored on the Customer's Data Warehouse 24. Accesses to this Metadata will be managed by the DSM 16. In order to optimize accesses to the Metadata, the DSM 16 will implement a shared memory, write through cache of the MDT tables.

Each User 1405 will use only a subset of Metadata, and for practical reasons that data will be re-organized from flat tables of the database into an application specific structure. Each of the User's Serial and Concurrent instances 2512, 2514 will need to keep a copy of this subset. This image will be constructed and maintained by the DAI 14.

When a User 1405 modifies a Metadata item, the DAI 14 will effect the change to the local image and will command the DSM 16 it update the data warehouse 24. The DSM 16 will write this change into the shared memory cache and through the cache to the warehouse 24.

The relationships and operations on Metadata are illustrated schematically in FIG. 26. The light arrows 2601

represent attachments to the shared memory Metadata Cache 2610. The bold arrows 2602 represent the path of Metadata.

The present MDT invention will maintain a single Scheduler Queue which will list all of the InfoFrame Requests scheduled to execute at some future time or to execute at regular intervals.

When the User 1405 schedules an InfoFrame Request through the Client 12, the Schedule Request will be passed through the Serial instance 2512 to the Scheduler 18. The Scheduler 18 will accept the Request and will place the Request in the Schedule Queue. When the User 1405 deletes a Scheduled Request the Scheduler 18 will delete the Request from the Scheduler Queue. The DAI 14 will also accept a User's Schedule Status Requests. It will satisfy them by inspection of the Scheduler Queue.

At regular intervals, the Scheduler 18 will inspect the Scheduler Queue, will identify Requests that have come due and will pass them to the Dispatcher 2513. The Scheduler 18 will then remove non-recurring Requests from the Scheduler Queue.

The Dispatcher 2513 will create a Concurrent instance 2514 to execute the Requests. A Concurrent instance 2514 is a process and expect processes should be a limited resource which must be managed by the Dispatcher 2513. Thus, an InfoFrame Request passed to the Dispatcher 2513 may exist in one of two states: (1) pending (waiting for a process) and (2) Executing. The Dispatcher 2513 will keep a list of Pending and Executing Requests. When the User 1405 makes an InfoFrame Status Request, the Client 12 will pass it to the Serial instance 2512 and the DAI 14 will implement it. It will need to collect the list of the User's Request status from the Dispatcher 2513 to complete the Status Request.

The relationships and operations on the Scheduler Queue 2710 are illustrated schematically in FIG. 27. The path of the InfoFrame Request is represented by the black arrows 2701. Status Information regarding scheduled Requests and Pending or Executing Requests, which must be collected by the Serial instance in response to the Client's status Requests, is represented by White arrows 2702.

Completed InfoFrames will be parked in the Return Area between the time they are completed and the time the Client 12 calls to collect them. The Return Area is simply a directory on the file system. It will contain a sub-directory for each user 1405.

When the Concurrent instance 2514 completes an InfoFrame Request it will copy the InfoFrame into the User's sub-directory of the Return Area. Recurrent Requests may leave many InfoFrames in the Return Area. The Concurrent instance 2514 must generate unique names for each Report.

The Client 12 will occasionally pass InfoFrame Status Requests to the Serial instance 2512. The DAI 14 will implement the Request. The DAI 14 will need to inspect the User's sub-directory of the Return Area to identify the InfoFrames that have been completed. The DAI 14 might 'decode' the file names to produce Analyst names and execution dates to report to the Client 12.

The Client 12 will also occasionally pass InfoFrame Upload Requests to the Serial instance 2512. The DAI 14 will implement the Request. The DAI 14 will collect the InfoFrame from the User's sub-directory of the Return Area. It will pass the InfoFrame to the Client 12 and will remove the image from the Return Area when the Client 12 acknowledges receipt.

The relationships and operations on the Return Area 2810 are illustrated schematically in FIG. 28. The flow of the completed InfoFrame is represented by the black arrow 2801. The movement of status required by the Serial instance 2512 to satisfy a Client Status Request is represented by the white arrow 2802.

1. DSM Subsystem 16

The DSM Subsystem 16 is described in further detail below.

The SQL Generator receives a Dimensional Query from the InfoFrame Generator, generates the necessary database queries, and returns the results to the InfoFrame Generator. The interface to the database is through ODBC, which takes queries in the form of SQL strings.

The SQL Generator must query the database 24 to evaluate each Measure/Segment pair. The Measures may be from the dai_MeasureList. In the first form of QueryDatabase( ), the segments are the child segments of the targetPartition; in the second form, each Measure is evaluated only for the implied target segment. Each of the measures may be a Composite Measure, which may require multiple queries to evaluate the Measures that make up the Composite Measure.

Standard SQL programming techniques may be used to implement the DSM Subsystem 16.

2. Scheduler Subsystem 18

The scheduler subsystem 18 is described in further detail below.

The scheduler subsystem 18 is responsible for submitting Analysts with schedules and/or triggers to be run. It is also responsible for maintaining lists of scheduled and/or triggered Analysts; deleting, modifying and adding to those lists.

In this section, an Analyst which has a schedule, a trigger, or a schedule and a trigger will be referred to as a 'scheduled' Analyst unless there is a difference in the way the three types of Analysts behave.

When an InfoFrame request is received by the S-DAI subsystem 14A, it will be passed to the Scheduler subsystem 18 if it is associated with a scheduled Analyst. The Scheduler 18 will determine the proper time period in which to dispatch the Analyst. When it is scheduled to run, a request will be passed to the dispatcher 2513 as in the same manner that the S-DAI subsystem 14A passes non-scheduled requests.

FIG. 29 illustrates this process in further detail.

From the S-DAI 14A, the Scheduler 18 will receive scheduled InfoFrame requests, delete and disable user requests, delete scheduled Analyst requests. To uniquely identify requests, the S-DAI 14A must provide an Analyst id (contained in the InfoFrame request object) and a user id.

When a scheduled InfoFrame request is received, the Analyst is placed on the Trigger List 2901 if the Analyst has a trigger, or the Schedule List 2902 if it has either a schedule or a schedule and a trigger. The difference between a triggered Analyst and a scheduled, triggered Analyst is that the former is run at each trigger period while the latter is run only when scheduled.

The Scheduler 18 has two execution time periods, one for triggered requests and one for scheduled requests. The two time periods are configurable on each MDT server 32 and may be changed by the MDT Administrator.

When the trigger time period occurs, the Scheduler 18 traverses its list 2901 of triggered events. For those scheduled to run during that time slice and whose user account is enabled, a copy of the InfoFrame request without the trigger is passed to the Dispatcher 2513. An analogous process is followed for the schedule time period and schedule list 2902.

If a user 1405 is deleted, the Scheduler 18 will remove any Analysts from the lists which are owned by the deleted user. If a user 1405 is disabled, any Analysts on the lists will not run until the user 1405 is once again enabled. If an Analyst

is modified, the user **1405** must explicitly remove any associated scheduled requests or they will continue to run with the old Analyst definition.

Although the present invention has been described with particular reference to certain preferred embodiments thereof, variations and modifications of the present invention can be effected within the spirit and scope of the following claims.

What is claimed is:

1. A system for managing a database hierarchy, comprising:

(a) a database computer, including a data warehouse comprising data entities having associated attributes, wherein the data entities are arranged in a first hierarchy, each level of the first hierarchy being associated with at least one attribute;

(b) a server computer coupled to the database computer, wherein the server computer includes a data abstraction intelligence subsystem and a data and schema manipulation subsystem having:

(1) means for receiving an attribute restriction value for restricting a selected attribute; and

(2) means for partitioning and segmenting the database, wherein a second hierarchy is created, the second hierarchy being associated with the attribute restriction value; and

(c) a client computer coupled to the server computer, wherein the client computer includes:

(1) means for inputting from a user of the client computer the attribute restriction value; and

(2) means for transmitting the attribute restriction value to the receiving means of the data abstraction intelligence subsystem and the data and schema manipulation subsystem.

2. The system of claim **1**, wherein the data abstraction intelligence subsystem and the data and schema manipulation subsystem further include means for transmitting the second hierarchy to the client computer, and the client computer further includes means for receiving the second hierarchy from the data abstraction intelligence subsystem and the data and schema manipulation subsystem and displaying the second hierarchy to the user of the client computer.

3. The system of claim **1**, wherein the data abstraction intelligence subsystem and the data and schema manipulation subsystem further include means for querying the data entities within the database having the first hierarchy.

4. The system of claim **1**, wherein the data abstraction intelligence subsystem and the data and schema manipulation subsystem further include means for querying the data entities within the database having the second hierarchy.

5. The system of claim **1**, wherein the data abstraction intelligence subsystem and the data and schema manipulation subsystem further include means for querying the database.

6. The system of claim **5**, wherein the querying means comprises a SQL server.

7. The system of claim **5**, wherein the client computer further includes means for transmitting a query request to the querying means.

8. In a computer system comprising a client computer, a server computer coupled to the client computer, and a database coupled to the server computer, wherein the database contains data entities, and wherein the server computer includes a data abstraction intelligence subsystem and a data and schema manipulation subsystem, a process for managing a hierarchy associated with the database, comprising the steps of:

(a) associating attributes with the data entities;

(b) arranging the data entities in a first hierarchy, wherein each level of the first hierarchy is associated with at least one attribute;

(c) inputting from a user of the client computer an attribute restriction value;

(d) transmitting the attribute restriction value from the client computer to the data abstraction intelligence subsystem and the data and schema manipulation subsystem, the attribute restriction value restricting a selected attribute; and

(e) segmenting the database, wherein a second hierarchy is created, the second hierarchy being associated with the attribute restriction value.

9. A system for managing a database, comprising:

(a) a hierarchical database comprising data arranged in tables having columns;

(b) a server computer coupled to the database, the server computer including a data abstraction intelligence subsystem and a data and schema manipulation subsystem;

(c) a client computer coupled to the server computer, the client computer including means for receiving input from a user of the client computer,

wherein the system creates metadata concerning a particular business for use in partitioning and segmenting the database, the metadata being created by the following method:

(1) receiving as an input from the user a specified business concept;

(2) receiving as an input from the user one or more attributes for the specified business concept;

(3) providing to the user a list of columns of tables in the database;

(4) receiving as an input from the user a mapping of each attribute to a column in a table in the database.

10. A system according to the claim **9**, wherein the method for creating metadata includes the following additional steps:

(5) receiving as an input from the user one or more business indicators;

(6) providing to the user a list of columns of table in the database;

(7) receiving as an input from the user a mapping of each business indicator to a column in a table in the database;

(8) receiving as an input from the user an aggregate method for the mapped business indicators;

(9) receiving as an input from the user a selected unit of measurement for the mapped business indicators;

(10) ensuring that tables having mapped business indicator columns can be joined with tables having mapped business attribute columns.

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